Elevation

Cut Landfill Leachate Treatment Costs

Achieve 50% OPEX Savings with Advanced Membranes

ZwitterCo

Overview

Reverse osmosis (RO) membranes are a cornerstone in industrial applications, particularly when dealing with difficult to treat wastewaters like landfill leachate. However, despite their role in treating leachate for reuse or discharge, traditional RO membranes often face significant operational challenges which can increase downtime and operating costs.

High organic content in leachate often fouls the first pass of a multi-pass RO system. This means RO membranes may need to be cleaned as often as every few days and must be fully replaced every 6-12 months.

In the past 40+ years, membrane development has been mostly incremental, but new membrane chemistry has arrived in the market. ZwitterCo has developed two advanced products that use zwitterionic chemistry to mitigate organic fouling: ZwitterCo's advanced Expedition SF membrane, which can be used as RO pretreatment, and an advanced RO membrane. Our innovative membrane technology ensures reduced cleaning, which means less downtime, longer membrane life, and lower overall expenses.

What's Included

- → Identifying Problems with RO Membranes
- → Why ZwitterCo Membranes are Different
- → ZwitterCo Membranes in Action
- → Commercial Offering
- → About ZwitterCo

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Chapter 1

Challenges Assicoated with RO Membranes in Landfill Leachate

Leachate forms when water – typically from rain, snow, or intrinsic moisture present in waste – flows through a landfill and extracts soluble or suspended contaminants. Without proper containment, water that accumulates at the bottom of the landfill can seep into the environment and contaminate the soil and groundwater. Effective containment can mitigate the risk of environmental exposure, but the leachate must then be extracted and disposed of to maintain stability of the landfill.

Given the variability and complexity of these streams, leachate management has historically relied on hauling or transporting leachate to a Publicly Owned Treatment Plant (POTW) for offsite disposal. This simplified operations and minimized capital expenses and infrastructure maintenance for the landfill. However, POTWs are increasingly rejecting leachate due to rising public concerns and increasingly stringent state and federal regulations around persistent contaminants like PFAS and microplastics. With longer hauling routes, rising costs, and reduced security of leachate disposal options, landfill operators must rapidly consider onsite leachate treatment and management strategies.

The first-pass system 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.

One of the biggest challenges with RO systems in landfill leachate operations is membrane fouling. Because landfill leachate often has high levels of organic material (like TOC, COD, or BOD), the first-pass RO membranes typically suffer from fouling challenges. This means the membranes may be cleaned as often as every few days and fully replaced as frequently as every 6-12 months. This frequent maintenance is not only costly but also time-consuming, preventing operators from focusing on preventative maintenance or other critical tasks.

DOWNTIME DUE TO

Frequent Cleaning

RO membranes may be chemically cleaned to remove organic materials and recover performance. Cleaning, while necessary to maintain system performance, tends to heavily increase overall expenses. With each cleaning cycle requiring a temporary system shutdown, downtime from membrane cleaning can detrimentally affect operations.

Each time your system goes offline for a cleaning cycle, you sacrifice operator hours. This lost productivity can quickly add up,

HIGH OPEX DUE TO

Frequent Replacements

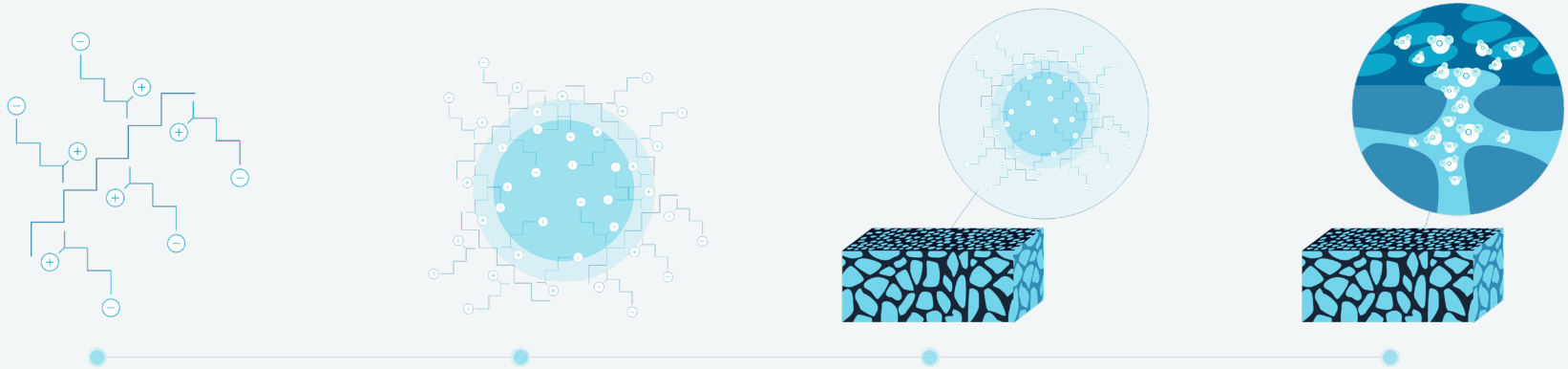
Every cleaning cycle chips away at the lifespan of your membranes, requiring you to replace your membranes more often. Whether planned or unplanned, the cost of new RO membranes can be a significant expense.

Frequent replacements not only increase overall costs but also contribute to additional downtime associated with installing and commissioning new membranes. Each replacement cycle requires taking the system offline, and frequent replacements often disrupt operations, leading to lost productivity on top of additional expenses.

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 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. With unmatched resistance to organic fouling, Elevation BWRO and Expedition SF membranes represent ZwitterCo's next-generation membrane platform. While each product is engineered for standalone performance, Expedition SF has demonstrated particular value as pretreatment to RO—offering additional assurance in the most demanding applications

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.

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

Not only can Elevation RO membranes reduce your overall operating expenses (OPEX) by at least 50% over two years, 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).

A leachate treatment system using 30 x 8040 RO elements could **reduce annual cleaning costs by over $45,000** when switching to Elevation RO.

Operational Benefits

Designed to offer stable performance even in high-fouling streams, ZwitterCo membranes can be fully restored with less frequent cleaning. This results in longer 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.

Chapter 3

ZwitterCo Membranes in Action

01. Improved RO Reliability for Complex Leachate

A landfill leachate treatment facility in France was experiencing significant operational challenges due to the complex and variable composition of the wastewater, which included elevated levels of organic compounds, nitrogen species, heavy metals, and inorganic salts. Conventional BWRO membranes suffered from **rapid fouling**, requiring daily clean-in-place procedures and element replacement every two to three months.

Various cleaning agents and alternative membranes were trialed but failed to deliver lasting improvement, resulting in high chemical consumption, increased operating costs, and system downtime. In early 2024, a membrane evaluation was initiated to assess the performance of **ZwitterCo Elevation High Rejection BWRO** membranes under standard site conditions and without modifying system design or control strategy. The ZwitterCo membranes were installed in one pressure vessel for side-by-side comparison with incumbent elements operating under identical feed and hydraulic conditions.

The membranes demonstrated stable flux, improved cleanability, and strong contaminant rejection across critical leachate constituents. Following performance validation, the full system was converted. Cleaning frequency dropped from 7 to 4 times per week using a simplified protocol, reducing chemical usage, cleaning water consumption, and membrane replacement frequency. Cleaning-related operating costs were reduced by ~50% per m^3, and treated permeate consistently met reuse targets for non-potable applications such as truck washing and dust suppression.

The evaluation confirmed that ZwitterCo Elevation elements deliver long-term process stability and cost-efficiency under demanding landfill leachate conditions.

KEY HIGHLIGHTS

- Membrane replacement frequency **decreased by 65%**
- **~50% reduction** in cleaning cost per m^3
- Cleaning water usage **reduced by 43%**

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02. Tackling Escalating Leachate Management Costs

A landfill in Europe faced a costly challenge: treating high-strength leachate with conventional reverse osmosis (RO) membranes. Frequent organic fouling meant the system required regular cleanings using expensive, specialty-formulated chemicals—each cleaning costing over $120. The constant need for intervention drained resources, strained operations, and made it difficult to maintain compliance without significant downtime and budget pressure.

Looking for a more sustainable and cost-effective solution, the facility turned to ZwitterCo Elevation RO membranes. Designed with organic fouling-resistant ZwitterShield™ technology, the membranes were seamlessly integrated into the existing treatment process. Almost immediately, they began delivering results. Fouling rates dropped significantly, and the site was able to shift from high-cost formulated cleaners to low-dose generic alternatives, bringing cleaning costs down to just $5 per clean.

With less frequent cleanings and more reliable performance, the plant saw immediate operational improvements. Downtime decreased, allowing for more consistent treatment, and the shift to low-dose generic cleaners dramatically lowered operating costs. As the membranes continued to perform, the facility maintained stable throughput and extended membrane lifespan, all while significantly reducing the reliance on costly specialty chemicals.

KEY HIGHLIGHTS

- **>20x lower cleaning costs** by switching from formulated cleaners ($120+ per clean), to low-dose generic cleaners ($5 per clean)
- **Reduced downtime**, ensuring more efficient and continuous operations
- **Sustainable performance**, extending membrane lifespan and reliability

03. Going Beyond Pretreatment: The Power of **Expedition SF** for Leachate Treatment

A U.S. landfill was struggling to manage leachate effectively. With minimal treatment before deep well injection, the site experienced persistent fouling and plugging of the well. These issues forced frequent maintenance, created operational downtime, and required costly offsite hauling and disposal of excess leachate—placing ongoing strain on both staffing and budgets.

To address the problem at its source, the facility installed ZwitterCo Expedition SF membranes, which are engineered to withstand the organic fouling typical of high-strength wastewater. The membranes helped to remove the organic contaminants that had been driving well failure, resulting in significantly more stable well performance.

The system was originally piloted as pretreatment ahead of RO, but the Expedition SF membranes alone delivered better-than-expected results. Effluent from the SF system met the injection well's quality requirements without the need for additional polishing. Performance remained consistent with only a simple weekly maintenance wash, eliminating the need for more intensive cleanings or chemical support.

By replacing a maintenance-heavy approach with a reliable treatment solution, the landfill was able to stop hauling leachate offsite, prevent ongoing fouling of the well, and significantly reduce its operating costs. What began as a pilot for pretreatment ended as a complete solution.

KEY HIGHLIGHTS

- **Eliminated costly leachate hauling** and offsite disposal
- **Prevented injection well fouling** and reduced maintenance burden
- **Generated significant operational savings** with reliable long-term performance

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04. Tackling Leachate Challenges at a Southwestern European Landfill

A landfill in southwestern Europe was experiencing ongoing operational and financial strain while managing high-strength leachate. The site's first-pass reverse osmosis (RO) system required frequent cleanings using costly formulated chemicals, which drove up expenses and slowed down operations.

To address these challenges, the site installed ZwitterCo Elevation RO membranes in the first-pass position. Specifically built for challenging leachate applications, the membranes were easy to install and have provided consistent, reliable performance through four months of continuous operation.

The pilot has already demonstrated meaningful operational and economic benefits. Chemical cleaning costs have been slashed by more than 90% through simplified, more effective cleaning protocols. Unlike traditional membranes, ZwitterCo's technology consistently recovers fully after each cleaning cycle, reducing downtime and enabling continuous, reliable throughput. In parallel, the system has shown improved normalized flow and a steady decline in operating pressures—early indicators of sustainable membrane health and long-term viability.

KEY HIGHLIGHTS

- **Over 90% reduction** in chemical cleaning costs through simplified cleaning
- **Less downtime and full recovery** after each clean
- **Improved normalized flow** and decreasing operating pressures, with continued sustainable performance

Chapter 4

Commercial Offering

Expedition

ZwitterCo Expedition SF membrane elements are available in a range of commercial sizes, including 8040 and 4040 spiral wound elements. They are available from stock or with short lead times for rapid deployment.

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ZwitterCo Elevation RO membrane elements are available in standard 8040, 4040, and 2540 sizes across three commercial variants: High Rejection BWRO, Low Energy BWRO, and High Pressure RO. These elements are typically available from stock or with short lead times to support rapid deployment and system replacements.

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 contact us directly for more information.

ZwitterCo

ZwitterCo is the global leader in membrane solutions for challenging separations, helping industries treat complex wastewater, purify water for reuse, and maximize efficiency in food processing applications. The company leverages its breakthrough zwitterionic chemistry to build membranes with unprecedented fouling resistance, overcoming the longest-standing limitation with conventional filtration. Manufacturers in more than 20 countries across food and beverage, agricultural, and industrial sectors rely on ZwitterCo's membrane solutions to achieve their most ambitious sustainability and growth targets.

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