

Demonstrating Cost-Effective Cleaning and Stable Membrane Performance

with AST Advanced RO Membrane System Leveraging ZwitterCo Elevation RO for Landfill Leachate Treatment



Fast Facts

Project Partner	AST
Industry	Water & Wastewater Treatment Solutions
Application	MSW Landfill Leachate
Location	Portugal
Treatment System	ASTRO System leveraging ZwitterCo Elevation RO
Membrane Technology	ZwitterShield™
Element Type & Model	Elevation High Pressure RO 8040-34
System Operating Conditions	Capacity: 7 GPM (40 m³/d) Avg. Operating Pressure: 728 psi (50.2 bar) Feed temperature: 55-74°F (13 to 23°C)
Year of Installation:	2024

The Opportunity

AST is a Portugal-based environmental technology company with a strong reputation for delivering advanced solutions in water purification, effluent treatment, and waste recovery. Known for its expertise in treating complex wastewater, AST designs and delivers fully automated and compact membrane treatment systems enabling flexible deployment while meeting stringent environmental and regulatory standards.

AST consistently adopts the most advanced technologies to achieve high performance, ensure environmental compliance, and maximize economic efficiency for its customers. AST's multidisciplinary team specializes in landfill leachate treatment using direct spiral-wound RO membranes. They are a leader in leachate treatment in Brazil, Portugal, and Spain and have a record of successful installations across Europe, South America and Africa.

For this project, AST deployed a fully automated and equipped two-pass RO system in standard 8040 format for a six-month demonstration at the customer's site.

Key Highlights

- **Cleaned with commodity chemicals** (caustic + acid) only, eliminating reliance on formulated cleaners
- Achieved a **96% reduction in cleaning costs** compared to conventional RO cleaning protocols
- Maintained **full normalized flow recovery** after each CIP with **no signs of irreversible fouling**
- Demonstrated **stable membrane performance over six months**, supporting longer membrane life and lower replacement frequency
- **Approved for 300 m³/day full-scale system**, validating sub-scale rental success and long-term reliability

The installation enabled the customer to operate a flexible, automated plant under varying feed conditions and evaluate system performance prior to full-scale deployment.

The Challenge

Landfill leachate is one of the most difficult wastewaters to treat, characterized by highly variable composition and elevated levels of salts, refractory organics, and trace contaminants. These conditions often result in membrane performance instability, frequent chemical cleaning, and reduced system recovery where operational reliability is essential.

The client had extensive experience operating plate-type disc-tube membrane systems, but faced challenges with recurring organic fouling, short membrane lifespans, and frequent cleaning using costly formulated chemicals.

To reduce operating costs and adopt a more modern membrane treatment system, the client began evaluating alternatives that could deliver greater reliability and lower the total cost of ownership. Any replacement system would need to meet strict performance objectives: permeate conductivity below 100 $\mu\text{S}/\text{cm}$, ammonia concentrations under 10 mg/L, membrane lifetimes exceeding one year, and a cleaning frequency of once per week or less.

To demonstrate this capability, AST deployed a 7 GPM (40 m^3/d), two-pass RO rental system, which served as a proving ground for a potential 55 GPM (300 m^3/d) full-scale installation. The demonstration system allowed the customer to validate membrane stability, cleaning behavior, and treatment outcomes under the variable feedwater conditions typical of landfill leachate.

The Solution

AST deployed ASTRO, an advanced RO membrane system leveraging ZwitterCo Elevation High Pressure RO membranes. **These membranes were powered by ZwitterShield™ - an additive membrane technology that bonds ZwitterCo's patented zwitterionic chemistry to proven membrane chemistries to equip them with a permanent barrier to irreversible organic fouling.**

The membranes were installed in the first pass of a two-pass reverse osmosis (RO) treatment train. This configuration was selected to assess membrane performance under the higher organic loading

typical of first pass leachate treatment. A robust pretreatment system was implemented to ensure reliable RO performance and membrane protection. The pretreatment train consisted of a 100-micron bag filter followed by a 50-microns multimedia filter as shown in the process flow diagram (PFD) below. A 5-micron cartridge filter was installed downstream to serve as a final polishing step before RO, ensuring fine particulate removal. In addition to physical filtration, sulfuric acid was dosed inline ahead of the RO system to adjust and stabilize the pH, reducing the potential for scaling, while an antiscalant was also injected to inhibit precipitation of sparingly soluble salts. The system was operated with standard clean-in-place procedures including alkaline and acidic cleanings.

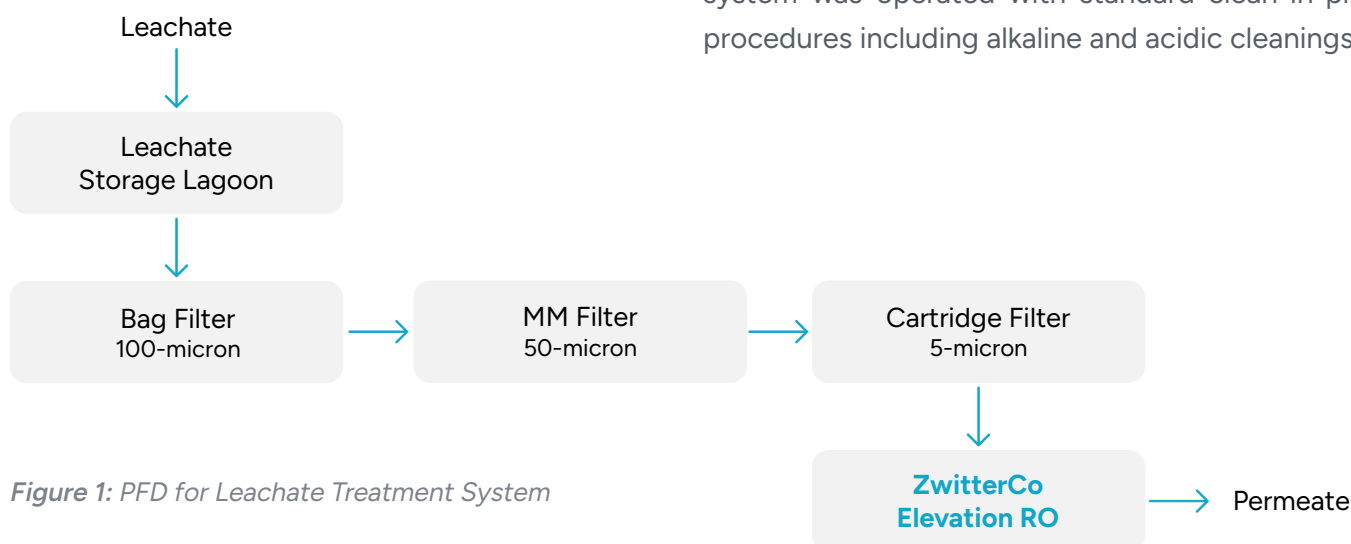


Figure 1: PFD for Leachate Treatment System

The Results & Benefits

Over the course of six months, the ASTRO system with ZwitterCo Elevation High Pressure RO membranes operated reliably at the landfill leachate treatment site, maintaining stable performance. Early in the trial, as feed pump flow increased in steps from approximately 7 to 14 GPM (1.8 to 3.0 m³/h), normalized permeate flow rose accordingly. By early February, the system had reached its maximum feed flow, as illustrated in Figure 2. From December to March, only alkaline cleanings were performed using sodium hydroxide at pH 11–11.5 and 59°F to 83°F (15°C to 28°C) for 100 mins. A water flush was also carried out every 72 hours to minimize foulant buildup and extend the interval between CIP events. Despite the absence of heated CIP capability, the system consistently recovered full performance after each cleaning.



ASTRO leachate treatment system with ZwitterCo Elevation High Pressure RO Membranes

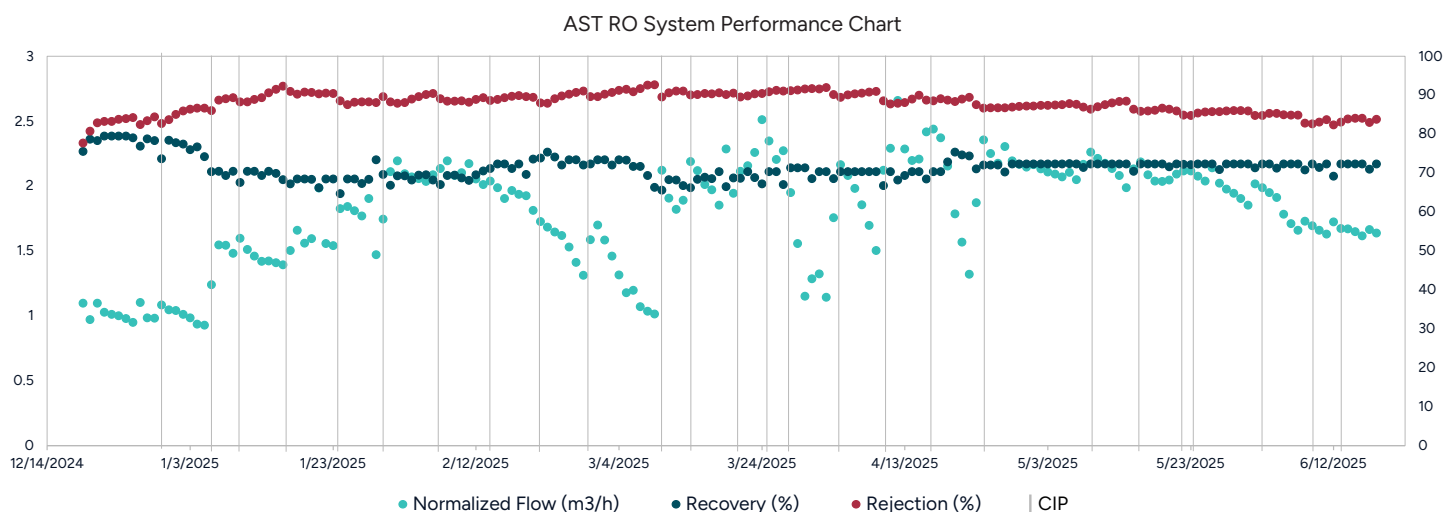


Figure 2: Elevation RO Operating Chart- Normalized Flow (m³/h), Recovery (%) and Rejection (%)

However, by late March, a decrease in normalized permeate flow was observed. The persistent drop suggested that alkaline cleaning alone was insufficient. Acid was introduced into the cleaning protocol for the first time in late March. The most effective cleaning occurred in late April, using a two-step procedure: acid at pH 2.6 followed by alkaline cleaning at pH 11.93, carried out at 21°C. This cleaning was described as highly effective, and it successfully corrected the normalized permeate flow decrease observed in the prior weeks.

Following this adjustment in cleaning strategy, the system stabilized. Operation between February and May was notably consistent, with normalized flow recoverable after each cleaning and no signs of permanent performance loss. Based on the trend data and recovery consistency, AST recommended reducing the cleaning frequency to once every two weeks, with combined acid and alkaline cleanings once per month. Salt rejection remained high with values consistently above 90%. A slight decline was observed toward the end of the monitoring period, which was likely tied to the feed water conductivity decreasing compared to the start of testing, resulting in a feed pressure of about 551 psi (38 bar) instead of the 870 psi (60 bar) pressure in the early demonstration stage. Importantly, permeate quality remained within the project specifications; conductivity remained below 100 $\mu\text{S}/\text{cm}$, and ammonia concentrations were consistently under 10 mg/L.

Perhaps most notably, the membranes were cleaned exclusively using commodity chemicals - caustic and citric acid - eliminating the need for formulated cleaners as shown in Table 1. This shift not only simplified plant operations but also reduced chemical costs per cleaning from an estimated €28 to just €1, representing a 96% cost reduction. Over the full duration of the demonstration period, membranes showed no signs of irreversible fouling or wear, with normalized flow fully recoverable after each cleaning. These results reinforced confidence in the membrane's ability to exceed the expected one-year service life.



ASTRO leachate treatment system with ZwitterCo Elevation High Pressure RO Membranes

Parameter	ZwitterCo Elevation RO	Conventional RO
Cleaning Chemicals & Frequency	1x/week Caustic + 1x/month Citric Acid (Started after 3.3 months of operation)	1x/week Formulated Cleaner + 1x/month Citric Acid
Chemical Cost per Clean	~1.07 USD (€1)	~30 USD (€28)
Membrane Life Expectation	No decline in normalized flow over 6 months	Membrane replacement every 1–2 years (typical)
Cleaning Recovery	Fully recovered even after rapid decline	Risk of irreversible fouling without Formulated Cleaner regimen

Table 1: CIP and Maintenance Comparison

Conclusion & Outlook

The ASTRO system with ZwitterCo Elevation High Pressure RO membranes demonstrated reliable performance in treating MSW landfill leachate. The membranes consistently met water quality targets, responded well to cleaning, and operated without the need for formulated cleaners - delivering both operational simplicity and substantial cost savings.

Despite the absence of heated CIP capability, the system consistently recovered full performance after each cleaning. The ability to restore normalized flow after cleaning, combined with no signs of irreversible fouling, supported the expectation of extended membrane life.



Based on the outcomes of the trial, the customer expressed strong satisfaction with system performance. As a result, the customer launched a tender for a full-scale system designed for 300 m³/day - marking a successful transition from a rental demonstration plant to a full-scale system, reinforcing the value of the solution for high-fouling landfill leachate treatment.



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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