VSEP Vibes Newsletter

Welcome to the New Logic Research Newsletter

When Spiral RO Hits the Wall, VSEP Takes Over

Spiral wound RO membranes are excellent technology developed in the 1960s for desalination of seawater. Over the years the use of these membranes expanded into other filtration applications including wastewater. These membrane elements are tightly wound layers of membranes wrapped around a center core where the permeate exits. There is a plastic netting material that provides a space between the membranes. The free space can be as little as 1 mm. These membranes are excellent for polishing relatively clean water or effluent, but, they have many limitations due to the laminar flow design and tight spaces.

When the wastewater gets more difficult, pretreatment is used to make the water clean enough to feed to a spiral. These membranes have zero tolerance for oil because of hydrophobic bonding and adherence to the plastic netting and membrane reducing the free space and blinding the membrane. Suspended solids are also not allowed as these will get caught in the netting and the element acts like a sock filter. UF pretreatment is needed before spiral RO. Spiral membranes cannot tolerate COD, BOD or TOC due to biological fouling. TOC is generally limited to 2 mg/L. There are scaling limits for silica, sulfates, and hardness, so, the solubility limit cannot be exceeded. Iron and Aluminum can form hydroxide precipitates that can foul, and so, the limit for these is 0.05 mg/L. So if you have water with SDI <5, O&G ~0 mg/L, <2 mg/L TOC, <1 NTU turbidity, Fe and AL <0.05 mg/L, and solubilities that are low enough, you can use a spiral. But this does not allow for most wastewaters.

Time and time again, we have seen people trying to use spiral membranes for a wastewater that is not suitable even with pretreatment. The temptation to use spirals is due to relatively low cost and excellent filtrate quality, when you can get it. There are many smart engineers out there who have tried all kinds of tricks to get these membranes to work on difficult effluents, but the result is often the same. I have also seen some membrane companies brag about their special fouling resistant membrane that can allow for changing every few months instead of every few weeks.

New Logic understood these limits and that is why we developed the vibratory VSEP with wide feed channels so that it would not have any of these limits. VSEP was specifically designed for difficult wastewater that spiral membranes could not do so that the excellent filtrate quality can be delivered where previously not possible. We say that the best application for VSEP is one where a person wanted to use a spiral but could not or really struggled. There are other examples such as the HERO system where pretreatment is so complex and extensive that the flow sheet takes many pages to capture and costs a fortune to operate.

We get called on all the time to do jobs where the customer has a dead spiral RO system. There have been dozens of examples. Currently, we are pilot testing a wastewater at a beverage plant where a spiral RO system could not perform. The customer for years has been changing the RO spiral elements twice per month. The cost and labor for this are enormous. The client has a discharge limit for BOD and the effluent has high BOD causing biological fouling of the spiral elements to the point where cleaning is ineffective. The image above is of the spiral elements they are removing for replacement.

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The Water Nobody Wants to Think About

Summer weekends are supposed to be about sunshine, crowded beaches, and cooling off in the ocean. Yet this year, New York City health officials issued swimming advisories for several city beaches after water testing found elevated levels of fecal-indicator bacteria, reminding beachgoers of an uncomfortable reality that most people would rather ignore. The water may look inviting, but after rainstorms, what enters it is often far less appealing.

For most visitors, a trip to the beach is an escape from the city. Families spread blankets on the sand, children splash in the surf, and few people spend much time wondering where the water came from or what has recently washed into it. Yet in a dense urban environment like New York City, millions of acres of rooftops, roads, parking lots, sidewalks, parks, and other hard surfaces collect everything that accumulates between rain events. When a storm arrives, that layer of urban grime begins to move.

Rainwater flowing across streets picks up oil residues, litter, sediment, animal waste, and other pollutants before traveling through storm drains and outfalls to nearby rivers, bays, and coastal waters. In many locations, stormwater receives little or no treatment before reaching the environment. In older portions of New York City, heavy rainfall can also contribute to combined sewer overflow events, where stormwater and wastewater exceed system capacity and are discharged to surrounding waterways.

The result is that elevated bacteria levels frequently appear after significant rainfall. In fact, New York City's beach monitoring program specifically tracks rainfall because wet-weather conditions are closely associated with increased bacterial contamination. Health officials regularly collect water samples and issue advisories when bacterial indicators exceed state standards for safe swimming. What many people do not realize is that the bacteria being measured are indicators of fecal contamination. The source may be birds, geese, dogs, urban wildlife, human sewage, or a combination of all of them. Authorities often cannot determine the exact source during routine monitoring. However, the elevated readings tell a clear story: fecal material has found its way into the water.

That creates an uncomfortable image. After a storm, swimmers may be entering water that is, in part, diluted urban wash water. The same rainfall that cleans streets, gutters, parking lots, and public spaces is carrying contaminants into the waterways where people seek relief from summer heat. The ocean provides enormous dilution, and health advisories are intended to protect the public when contamination becomes elevated, but the underlying process remains the same.

The recent New York City beach advisories are a reminder that stormwater pollution is not an abstract environmental issue. It is something people can encounter directly during a summer beach outing. While sunshine and warm temperatures attract crowds to the shore, the safest time to swim is often after nature and the city's drainage systems have had time to recover from the last rainstorm.

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VSEP – Increasing Crop Yield

Agriculture is entering a pivotal phase as increasing global food demand intersects with pressure to reduce reliance on synthetic fertilizers, mitigate environmental damage, and restore soil health. Among the most promising tools in this transition are biostimulants, naturally substances that enhance plant growth and resilience. Within this broad category, dissolved organic matter (DOM)–based biostimulants, especially those derived from humic substances, have emerged as the most scientifically validated and commercially successful. Their effects on nutrient uptake, soil function, and stress tolerance position them as essential in modern regenerative farming systems.

DOM biostimulants originate from the natural decomposition of plant and microbial material, producing a complex mixture of organic acids, phenolics, peptides, and other bioactive molecules. Among these humic substances are humic acids, fulvic acids, and dissolved humic substances (DHS). Humic and fulvic acids arise through long-term humification of organic matter in soils, peat deposits, and compost. These materials undergo microbial and chemical transformation, releasing water-soluble fractions into soil solution as dissolved organic matter. Studies show that dissolved humic substances exert significant stimulatory effects on plant nutrient uptake and metabolic pathways acting as a potent biostimulant. Commercial producers isolate humic and fulvic acids from peat, leonardite, compost extracts, and other organic sources to create standardized, concentrated liquid or dry formulations for agriculture.

Dissolved humic substances consistently exhibit the strongest direct effects on plant nutrient health, particularly nitrate uptake. Their ability to upregulate specific genes associated with high-affinity nitrate transport makes them the most potent biostimulant. Fulvic acids rank second due to their rapid leaf and root absorption and wide-ranging physiological effects. Their small molecular size allows them to penetrate membranes and deliver micronutrients efficiently, enhancing both photosynthesis and stress tolerance. Humic acids, although less soluble, are highly effective in soil-focused applications, where they greatly improve the soil environment and, in turn, crop performance.

DOM-derived biostimulants deliver a range of biological and agronomic benefits. DHS activates plant nitrogen metabolism genes improving nitrogen transport and more efficient nitrogen use. Humic acids bind micronutrients into plant-available forms and improve the microbial and water holding capacity of the soil. Humic and fulvic acids modulate signaling pathways giving plants better resilience during drought and heat conditions. Dues to increased nutrient use efficiency and stress resilience improvements, substantial yield and crop quality benefits are seen.

Harvesting and processing these humic materials can be difficult. New Logic has experience doing this similar to isolation studies where polyphenols are recovered from waste streams. The targeted organic molecule is bracketed using membranes that remove solids larger than the organic and then using membranes that are smaller to remove water and monovalent salts to then concentrate the dissolved organic matter. VSEP has been installed for three projects recovering water soluble biostimulants from ion exchange systems used to treat drinking water.

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The $9 Billion Dollar Lesson Learned

The 2014 coal-ash disaster in North Carolina stands as a stark warning about the hidden risks embedded in aging ash-pond infrastructure and the staggering cost of waiting for failure rather than preventing it. At Duke Energy's retired Dan River Steam Station, decades of coal combustion residuals had been stored in large basins. Beneath one of those ponds ran an aging 48-inch stormwater pipe. On February 2, 2014, that pipe collapsed, creating a direct hydraulic pathway from the ash pond into the Dan River. With no engineered barrier, the fly ash slurry rapidly discharged through the break.

The result was catastrophic. Approximately 39,000 tons of coal ash and 27 million gallons of contaminated wastewater surged into the Dan River, spreading a plume downstream roughly 70 miles into the Roanoke River and then into the Albemarle Sound. The discharge carried a mixture of arsenic, mercury, lead, selenium, and chromium. While some contaminants diluted in the water column, much of the ash settled to the riverbed, coating sediments and creating a long-term contamination source. Bottom-dwelling organisms were smothered, aquatic habitats were disrupted, and fish populations faced exposure to bioaccumulative toxins such as selenium. Communities downstream were forced to intensify drinking water treatment and monitoring to ensure safe water supplies, highlighting the immediate human dimension of the incident.

The financial consequences were equally severe. Duke Energy entered into federal agreements to fund cleanup, assessment, and long-term monitoring. The remediation costs are estimated at $3M for the actual clean up and $110M in state and federal penalties. Additionally as part of the settlement, an estimated $8-9 billion cost were incurred for upgrading existing ponds, installing groundwater monitoring, and providing long term environmental oversight. Beyond direct expenses, the company faced regulatory action,

reputational damage, and long-term liabilities that continue to influence coal-ash policy nationwide. These costs are vastly higher than the cost of a wastewater treatment system that could have prevented the problem.

What makes this incident instructive is that it was not caused by an extreme weather event or unforeseeable condition. It was the predictable failure of aging infrastructure beneath a wet storage system. Across the United States, similar ash ponds remain in service, many constructed decades ago with earthen berms and buried piping systems that degrade over time. The EPA regulates about 775 ash pond and has designated about 300 as high-risk ponds due to age and design.

Instead of indefinitely storing fly-ash leachate in large surface ponds, advanced treatment technologies such as VSEP reverse osmosis can process leachate continuously, producing clean effluent while concentrating contaminants into a manageable waste stream. These systems eliminate the need for large, hydraulic storage ponds altogether. Had such a system been deployed at Dan River, the ash basin would not have contained millions of gallons of contaminated water effectively removing the failure pathway that caused the disaster. In this sense, the lesson is clear: containment is not prevention. Moving from storage to treatment not only protects waterways and ecosystems, it removes the long-term liability and the enormous costs that follow.

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A City That Is Sinking on Borrowed Water

From the air, Mexico City looks like any other megacity - dense, vibrant, alive. But beneath its streets, a crisis is unfolding. The ground itself is sinking, not slowly over centuries, but rapidly, nearly 10 inches (25 cm) per year in some areas. Over the past century, parts of the city have dropped more than 12 meters (nearly 40 feet). Roughly two-thirds of Mexico City's water comes from a massive aquifer beneath the basin. But the math is doesn't work: the city extracts about 53 m^3/s of groundwater, while natural recharge is only about 23 m^3/s. Every day, the city withdraws a resource that is not being replaced. The deficit of hundreds of millions of cubic meters annually means the aquifer is steadily collapsing. And when aquifers collapse, they compact, permanently losing capacity.

This is the hidden danger. It's not just that the aquifer is being depleted, it is being destroyed. At some point, even if rainfall returns, the aquifer will not recover to its former capacity. The city is, quite literally, consuming its future water supply. To compensate, Mexico City reaches far beyond its natural basin. The Cutzamala system imports water from distant reservoirs, transporting it more than 125 kilometers and lifting it over 1,000 meters in elevation. It is one of the most energy-intensive water systems in the world. Every gallon requires electricity to climb mountains before it can flow downhill into homes. In a world increasingly constrained by energy concerns, this is a costly and fragile solution.

This story is not unique. California's Central Valley offers the same warning. There, decades of groundwater over-pumping for agriculture have caused land to sink as much as 28 feet (8.5 meters) in some areas. In parts of the San Joaquin Valley, subsidence has reached 9 meters (30 feet) historically, with localized sinking continuing at rates of up to 2 feet per year during droughts. Like

The bell towers of the Metropolitan Cathedral in Mexico City are leaning despite reinforcement

Mexico City, the Valley has learned that aquifer depletion is not just a water problem, it is a structural one, damaging canals, pipelines, and ecosystems. Yet Mexico City's situation is even more precarious. 22 million people having a reliance on a single overdrawn aquifer makes its trajectory unsustainable. If current extraction continues, the aquifer will not abruptly "run dry" one day—but it will become increasingly unreliable, more expensive to access, and physically diminished in capacity beyond recovery.

The lesson is clear, the time for planning is now. Groundwater alone cannot support megacities indefinitely. Imported water, while necessary, carries steep energy costs. The only durable path forward lies in closing the water loop by expanding reuse, improving recharge, and treating wastewater as an asset rather than a byproduct. Water reuse, once seen as optional, is quickly becoming essential infrastructure. Cities that invest now in advanced treatment, aquifer recharge, and circular water systems will be the ones that remain resilient. Mexico City is a glimpse into the future of water-stressed regions worldwide.

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Why Boron Is Closely Watched in Effluent Discharge

Boron occupies a unique and somewhat paradoxical place in water management. In very small amounts, it is an essential micronutrient, quietly supporting plant health and agricultural productivity. Yet, when concentrations rise even modestly above that narrow beneficial range, boron becomes a problem contaminant, capable of damaging crops, limiting water reuse, and complicating discharge compliance. This dual nature is exactly why boron is so often regulated in effluent discharge. At low levels, boron plays a vital role. It contributes to plant cell wall development, supports nutrient transport, and is especially important in reproductive processes such as flowering and seed formation. Without enough boron, plants can suffer from stunted growth, poor yields, and reduced vitality. In this sense, boron is no different from other micronutrients, necessary, but only in trace quantities.

The challenge arises because the gap between "beneficial" and "harmful" is unusually small. Elevated boron concentrations can quickly lead to toxicity, particularly in sensitive crops such as citrus, grapes, and many vegetables. Excess boron accumulates in plant leaves where evaporation occurs, causing tip burn, chlorosis, and reduced growth and yield. Over time, irrigation with boron-laden water can degrade soil quality and render land less productive. For this reason, agricultural reuse standards often drive boron discharge limits even more strictly than human health or aquatic life criteria.

One of the reasons boron shows up so frequently in wastewater is its widespread use in everyday products—most notably detergents and cleaning agents. Borates have long been used to enhance cleaning performance and stabilize formulations. As a result, boron enters municipal waste streams and ultimately becomes concentrated in residuals such as landfill leachate. In these environments, boron is highly soluble and resistant to biological treatment, allowing it to persist at elevated levels. Other industrial sources,

such as power generation, glass manufacturing, and produced water, further contribute to the challenge.

New Logic addressed this in a particularly demanding landfill leachate application characterized by both high ammonia and high boron concentrations. Successfully treating these contaminants required a carefully staged membrane approach using a VSEP RO system followed by two stages of spiral-wound RO polishing. What made this installation unique was the need for two distinct pH adjustments, a rare departure from typical RO system design, where pH is generally adjusted only once.

In the first stage, the pH is lowered to approximately 6.0–6.5. This converts ammonia (NH_3), which passes readily through membranes, into ammonium (NH_4^+), a charged species that is much more effectively rejected by RO. After this step, the permeate is then treated in a second stage where the pH is raised to around 10.5. At this higher pH, boron shifts from boric acid—which is poorly rejected by RO—to borate ions, which can be removed far more efficiently. This dual pH strategy highlights both the complexity of boron chemistry and the ingenuity required to manage it. It also underscores why boron remains a focal point in discharge regulations: it is not only a sensitive environmental parameter, but also a technically challenging one to control.

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Why POTWs are Saying No to BOD

Across the country, publicly owned treatment works (POTWs) are quietly reaching a tipping point. Designed decades ago for steady, predictable domestic wastewater flows, many plants are now operating at or near their maximum organic and hydraulic capacity. Population growth, tighter discharge permits, and evolving industrial activity have all contributed to the strain. As a result, POTWs are increasingly shifting responsibility upstream, requiring industrial users to pretreat their wastewater. At the center of this issue is biochemical oxygen demand (BOD), a key measure of the organic strength of wastewater. BOD represents the amount of oxygen microorganisms require to degrade organic material. While domestic wastewater has relatively consistent BOD levels, industrial discharges can be orders of magnitude higher and far more variable. These high-strength loads create significant challenges for biological treatment systems.

Most POTWs rely on activated sludge processes, where microorganisms metabolize organic matter in aeration basins. These systems are carefully balanced around three variables: food (BOD), biomass, and oxygen supply. When a sudden surge of high-BOD wastewater enters the plant—a "shock load"—it disrupts this equilibrium. The oxygen demand can quickly exceed the capacity of the aeration system, leading to low dissolved oxygen conditions. Without sufficient oxygen, biological treatment efficiency collapses, and partially treated wastewater can pass through the system.

Even when complete failure is avoided, excessive BOD loading creates cascading problems. Higher organic loads stimulate rapid microbial growth, producing more sludge than clarifiers and downstream handling systems are designed to manage. This can lead to poor solids settling, sludge blanket buildup, and increased suspended solids in the effluent. In plants with nutrient removal requirements, high BOD can also interfere with nitrification, as oxygen and reactor capacity are diverted away from ammonia-oxidizing bacteria. The result is an elevated risk of permit violations. From an engineering standpoint, every POTW has a finite

capacity expressed not just in flow (million gallons per day), but in pounds of BOD per day. Industrial users can consume a disproportionate share of that capacity with relatively small volumes of high-strength waste. As many plants approach these limits, operators face a difficult choice: invest in major capital expansions or control loading at the source.

Expanding a POTW is rarely a quick solution. Biological treatment capacity increases require additional tankage, aeration equipment, clarifiers, and often sludge processing systems. These projects are extremely expensive, often costing tens or hundreds of millions of dollars, and can take years—or even a decade—to permit, design, and construct. Moreover, expansions frequently trigger stricter regulatory requirements, including tighter effluent limits for nutrients and additional environmental reviews. Faced with these realities, municipalities are increasingly turning to industrial pretreatment as the more practical path forward. By imposing BOD limits or surcharges, POTWs encourage industries to install equalization, primary treatment, or high-rate biological systems on-site. This approach not only protects the stability of the municipal plant but also ensures that the costs of treating high-strength waste are borne by those who generate it, rather than by residential ratepayers. In today's constrained regulatory and economic environment, shifting the burden upstream is not just a trend—it is fast becoming a necessity for maintaining reliable and compliant wastewater treatment.

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Taming the Orinoco: Why Pretreatment Matters for Caribbean Desalination

Standing on the coast of Trinidad, the ocean can take on a surprising color, no longer the deep blues of open water, but a hazy, sediment-laden brown. This transformation is driven by one of the largest river systems on Earth: the Orinoco. Each year, this immense river discharges on the order of 90 to 150 million tons of sediment into the Atlantic Ocean, forming a plume that stretches far beyond Venezuela and into the Caribbean basin. This plume is not just a geographic curiosity, it is an operational reality for desalination plants in Trinidad. Fine silts and clays, carried thousands of kilometers from the Andes, remain suspended in the water column and are transported by regional currents into intake zones. The result is seawater with persistently elevated turbidity and high organic load, conditions that challenge even the most modern reverse osmosis (RO) systems.

About a decade ago, a visit to a desalination facility in Trinidad revealed just how severe this challenge can be. The plant relied on conventional pretreatment and spiral-wound RO membranes, an efficient and widely adopted technology under normal conditions. However, the feedwater quality was anything but normal. Pretreatment filters were fouling rapidly, forcing frequent replacement and increasing both operating costs and downtime. The issue was not salinity; it was the sheer burden of suspended solids, colloidal material, and organics coming from the Orinoco plume. In seawater desalination, turbidity is more than a nuisance, it is a performance limiter. RO membranes require very clean feedwater, typically below ~1 NTU, to avoid fouling. When turbidity rises, particulate and organic matter accumulate on membrane surfaces, causing flux decline, increased pressure requirements, and shortened membrane life. Conventional pretreatment, media filtration, coagulation, or even ultrafiltration, can struggle to maintain consistent performance under such highly variable and challenging conditions.

VSEP CEO, Greg Johnson, visiting the Desal Plant

This is where VSEP systems, come into focus. Unlike traditional membranes, VSEP uses high-frequency vibration at the membrane surface, generating intense shear forces that prevent the buildup of fouling layers. Instead of trying to keep solids away at all costs, VSEP systems are designed to handle high suspended solids and organics directly, maintaining stable flux even in difficult feedwaters.

In the context of Trinidad, this capability is particularly compelling. The Orinoco plume delivers not only high turbidity but also fine particles that are notoriously difficult to settle or filter. VSEP's shear-enhanced filtration can effectively remove these particles, along with dissolved organics, producing a much more stable and low-fouling feed stream for downstream spiral RO. In essence, VSEP acts as a buffer between a highly dynamic natural system and a process that demands consistency. For regions influenced by major river plumes like the Orinoco, this kind of resilience is not a luxury, it is a necessity. As desalination continues to expand in challenging coastal environments, the lesson from Trinidad is clear: understanding the source water is critical, and matching it with the right pretreatment technology can make the difference between chronic operational struggle and long-term success.

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Anaerobic Digester, VSEP, and the Value of Biosolids

Across municipal and agricultural systems, nutrient-rich feedstocks such as biosolids and manure have long been viewed as waste streams requiring careful management. Today, however, they are increasingly recognized as valuable resources, especially when stabilized through anaerobic digestion and further refined using advanced separation technologies. Anaerobic digestion (AD) is the cornerstone of this transformation. In a sealed, oxygen-free environment, naturally occurring microorganisms break down organic matter in15 to 30 days. During this process, complex organics are converted into methane biogas producing a residual material known as digestate. Importantly, AD does far more than reduce odors and volatile solids, it also significantly reduces pathogens.

Pathogen reduction in an anaerobic digester occurs through multiple mechanisms. Temperature plays a central role. Mesophilic digestion (~35–40°C) creates conditions that weaken and gradually inactivate many harmful organisms, while thermophilic digestion (~50–57°C) can achieve near-complete pathogen destruction. These elevated temperatures disrupt cellular proteins and membranes, effectively disabling bacteria, viruses, and parasites. Equally important is time. Pathogens exposed to prolonged retention under anaerobic conditions face nutrient deprivation, metabolic stress, and continual exposure to inhibitory compounds. The digestion process generates naturally hostile byproducts such as ammonia, volatile fatty acids, and hydrogen sulfide, all of which impair pathogen survival by disrupting cellular functions and damaging membranes.

At the same time, the dense microbial community inside the digester outcompetes and, in some cases, consumes pathogenic organisms. This biological competition, combined with chemical stressors and sustained exposure, creates an environment where

pathogens cannot persist. The result is a stabilized, significantly safer material suitable for downstream use. Once digestion is complete, the digestate undergoes coarse solids removal, typically via thickeners, to separate fibrous material and large solids (>100 microns). What remains is a nutrient-rich liquid containing nitrogen, phosphorus, potassium, and dissolved organic compounds. This is where advanced membrane technology such as VSEP reverse osmosis comes into play.

VSEP RO systems are uniquely suited to handle challenging, high-fouling streams like digestate. By applying vibratory shear at the membrane surface, VSEP minimizes fouling achieving high recovery rates. Wide spaces between the membranes allow for free flow of suspended solids without plugging the filter. The system separates clean permeate from a concentrated stream, effectively reducing volume by up to 80%. This concentration step transforms digestate into a dense, transportable, and nutrient-rich fertilizer product. Because upstream anaerobic digestion has already stabilized the material and reduced pathogen levels, the final organic rated product is both agronomically valuable and safe for land application. Additionally, the significant volume reduction lowers hauling costs making drying and nutrient reuse more economically viable.

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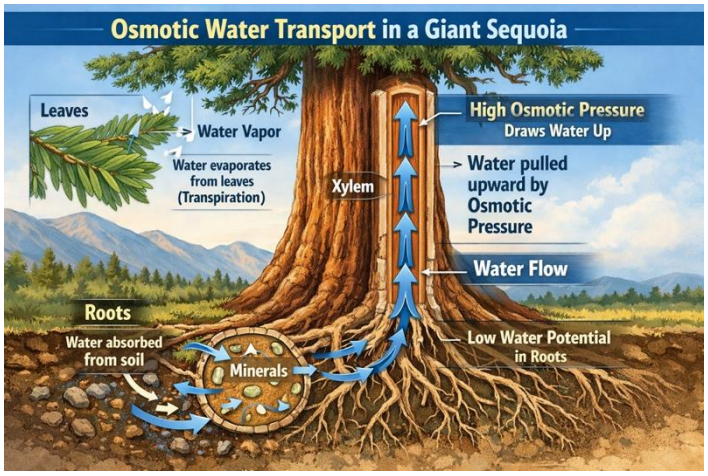
The Force That Moves Life: Osmotic Pressure

Beneath the visible rhythms of life, breathing lungs, flowing blood, stretching roots, there exists a silent, persistent force shaping every living system: osmotic pressure. It is not dramatic or easily seen, yet without it, life as we know it would simply not exist. This fundamental physical principle governs how water moves, how nutrients are absorbed, and how cells maintain their delicate balance. At its core, osmotic pressure arises from a simple natural tendency: systems move toward equilibrium. When two solutions of differing concentrations are separated by a semipermeable membrane, one that allows water through but not dissolved solutes, water flows toward the side with higher solute concentration. This movement dilutes the concentrated solution and equalizes conditions. It is not a process driven by intention but by probability and energy minimization, the universal laws that govern matter itself.

In animal cells, osmotic pressure becomes a silent partner in survival. Consider the transport of glucose and amino acids, the building blocks of energy and proteins. As these molecules accumulate inside cells, they increase the internal solute concentration. This creates an osmotic gradient that draws water inward. That influx of water maintains cellular volume and helps facilitate the continued uptake of nutrients through transport proteins embedded in the membrane. In tissues such as the intestines, this principle becomes even more pronounced: as glucose and amino acids are actively transported into cells, osmotic pressure pulls water along with them, enabling efficient absorption into the bloodstream. Thus, osmotic pressure does not carry nutrients directly, but it creates the conditions that make their movement possible.

Plants, rooted and immobile, depend on osmotic pressure even more profoundly. Beneath the soil, root cells maintain higher solute concentrations than the surrounding groundwater. This difference draws water into the plant through osmosis, filling cells and generating what is known as turgor pressure. This internal pressure stiffens plant tissues, allowing stems to



stand upright and leaves to spread toward the sun. More importantly, it creates a continuous flow of water from roots to shoots, carrying dissolved minerals upward. Without osmotic pressure, plants could neither hydrate nor nourish themselves, and terrestrial ecosystems would collapse.

Yet this same force that draws water inward presents a challenge in engineered systems. In membrane filtration processes designed to remove water from solutions, such as desalination or wastewater treatment, osmotic pressure must be overcome. Because water naturally moves toward higher solute concentrations, extracting pure water from a concentrated solution requires applying external pressure greater than the osmotic pressure itself. This reverses the natural flow, forcing water molecules back across the membrane in the opposite direction. This principle, known as reverse osmosis, is a direct confrontation with nature's preferred state, requiring energy to impose order against thermodynamic tendency. Osmotic pressure exists because of the fundamental drive toward equilibrium, a principle woven into the fabric of physics. Yet from this simple rule emerges immense complexity: nutrient transport in animals, water uptake in plants, and technologies that sustain modern life. It is a quiet reminder that even the most essential forces often operate unseen, shaping life one molecule at a time.

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Beverage Makers Are Redefining Water Efficiency

For decades, water sustainability in the beverage industry was defined by a simple promise: give back what you take. Leading producers invested heavily in watershed restoration, groundwater recharge, river rehabilitation, and community water access. But inside bottling plants around the world, another realization has taken hold. The greater opportunity lies upstream, in understanding exactly how water flows through the plant, how much is consumed, and how much is lost. Beverage companies are now measuring water with the same rigor they apply to energy, yields, and raw materials. Water intake is tracked against output.

The Coca-Cola Company, whose operations span hundreds of bottling facilities globally, has long emphasized water stewardship as foundational. Beyond its high-profile commitment to replenish more than 100% of the water used in finished beverages, Coca-Cola has focused intensely on reducing water use at the plant level, particularly in facilities located in high-risk watersheds. The company is reinforcing the idea that the most sustainable liter is the one never withdrawn in the first place.

PepsiCo has reached similar conclusions. Under its PepsiCo Positive (pep+) strategy, the company committed to becoming net water positive by 2030. Central to that ambition is water efficiency. PepsiCo has driven continuous reductions in water withdrawn per unit of production through improved process controls, reuse, and higher-yield treatment systems.

Across the industry, those efficiency gains are increasingly determined by what happens around membrane systems. Reverse osmosis remains essential for producing consistent, high-quality process water, but conventional spiral-wound RO systems inherently leave water behind. Historically, 15 to 25 percent of feedwater exits the plant as reject, a stream too valuable to ignore in regions under water stress. As companies scrutinized these losses, rejected water emerged as one of the largest controllable inefficiencies inside a bottling plant. Recovering that water became a technical challenge, but also a strategic one. Pushing recovery higher meant reducing freshwater intake, lowering wastewater discharge, and improving water-use ratios, all metrics increasingly visible to regulators, investors, and communities.

This is where high-recovery technologies have begun to quietly reshape water performance inside beverage facilities. Vibratory Shear Enhanced Process (VSEP) membrane systems have been installed at many bottling plants specifically to treat spiral RO reject streams. By using vibrational energy to prevent fouling and scaling, VSEP systems are able to concentrate reject water far beyond the limits of traditional membranes. In practice, this has allowed facilities to recover nearly all remaining water from RO reject and push total plant water recovery as high as 98 percent. The implications are significant. At that level of recovery, water efficiency becomes exponential. Every additional point of yield reduces raw water withdrawals, decreases wastewater volumes, and tightens the gap between water consumed and water produced. For sustainability teams pursuing water-neutral or water-positive targets, these operational gains directly reduce the burden placed on replenishment projects downstream.

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Lessons from the Cameco McClean Lake Sulfuric Acid Plant Outage

The uranium industry received a reminder this week that sometimes the most critical piece of equipment in a mining operation is not the mine itself. Cameco announced a temporary suspension of mining at its world-class Cigar Lake uranium mine after operational challenges forced a shutdown of the sulfuric acid plant at Orano's McClean Lake mill, where Cigar Lake ore is processed. Without sufficient sulfuric acid, the mill could not continue normal uranium processing, and with limited ore storage capacity available, mining operations were halted until acid supplies could be restored. Orano is currently repairing the acid plant while exploring alternative sources of sulfuric acid to resume milling operations.

While the specific cause of the outage has not been publicly disclosed, sulfuric acid plants are highly integrated systems where a failure of a single critical component can shut down an entire operation. Common failure points include main air blowers, sulfur burners, catalyst converters, waste heat boilers, acid circulation pumps, and absorption towers. Major blower failures, heat exchanger leaks, catalyst bed problems, corrosion damage, or pump failures can require specialized replacement parts and extended repair periods. In many cases, these failures immediately halt acid production because the process cannot safely operate in a degraded condition.

The consequences extend far beyond the acid plant itself. Sulfuric acid is the primary reagent used to leach uranium from ore at McClean Lake. Once acid production stops, ore processing slows or ends, mining inventories build, storage capacity fills, and eventually mining must stop. The acid plant effectively becomes a single point of failure for the entire operation.

This challenge highlights the growing interest in technologies that can reduce dependence on fresh acid production. New Logic Research is currently finalizing a major order for a 72-module VSEP® nanofiltration (NF) system at the Arafura Nolans Rare Earth Project in Australia. The system is designed to recover and recycle phosphoric and sulfuric acid from spent leach solutions while simultaneously removing contaminants, including radioactive thorium and uranium, from the recycle stream. Rather than sending spent acid to neutralization and disposal, the VSEP system separates and recovers reusable sulfuric acid for return to the process. The VSEP technology utilizes high-shear vibratory membrane separation, allowing it to process difficult mining solutions that typically foul conventional membrane systems.

The benefits of sulfuric acid recycling are substantial:
Reduced load on sulfuric acid plants
Lower sulfur consumption
Reduced dependence on sulfur deliveries
Lower acid plant operating costs
Reduced greenhouse gas emissions - sulfur burning
Lower lime and neutralization reagent consumption
Reduced tailings generation
Smaller tailings storage requirements

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Reduced water consumption
Improved process sustainability
Reduced risk associated with acid plant outages
Improved operational resilience
Reduction in permitting and environmental liabilities
Lower overall operating costs per pound produced

For operations that consume large volumes of sulfuric acid, including uranium, rare earth, nickel, copper, lithium, and other hydrometallurgical facilities, the economics of acid recovery can be compelling. Every ton of acid recycled is a ton that does not need to be manufactured, transported, handled, and ultimately neutralized.

As the recent McClean Lake outage demonstrates, sulfuric acid is not simply another process reagent, it is often the lifeblood of the entire operation. Technologies that recover and recycle acid can provide both significant cost savings and an additional layer of operational security when acid production becomes constrained. For many mining operations, acid recovery may represent one of the largest remaining opportunities to reduce operating costs while improving environmental performance.

Thank you for subscribing to our newsletter. I hope you find it informational and fun. You are one of 3,600 professionals and industry stakeholders who receive this newsletter each month.

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