VSEP Vibes Newsletter

Welcome to the New Logic Research Newsletter

Northern Wastewater Challenges

Working in cold climates presents a wide range of challenges. New Logic has installed equipment on all continents in all kinds of climates. When working on projects in the far north, we make special design considerations. Our cold weather chemical engineer, Oleg Tcabilev, states that designing for cold weather is not just about a few specific measures, rather it is a complete new way of thinking when it comes to plant design. It is very difficult to account for all the possibilities and the risk of accidents is high. Due to extreme cold in the winter, the equipment must be kept in a temperature controlled building. But often tanks and piping are outdoors next to the building. They will require insulation and heat tracing. One project we did in Northern Alberta at a pig farm experienced a lot of problems with pipes outside the treatment building freezing or bursting.

With many projects, pond storage of effluent is used due to the volumes needed. Tank sizes needed along with heating would make tanks storage impractical. New Logic also installed a VSEP system in Lithuania for biogas effluent where they were only able to land apply digestate for a few months out of the year when the ground was not frozen. Land was not available for storage ponds and so a large tank farm was used and managing the effluent volume became critical. The VSEP was used to minimize the effluent volume during the winter.

There are many types of projects that use storage ponds. These can include mine tailings, pig or cow manure slurries, and landfills for the storage of leachate. Even with large storage ponds, freezing temperatures can cause all kinds of problems. Depending on the salt concentrations, these liquid ponds can freeze and often at temperatures similar to fresh water. Ice forming on ponds can lead to blockages of drainage systems and possible

Leachate Storage at an Estonia Landfill

overflow situations. Ice in ponds can also pose a risk to the pond structure itself and the liners used as the ice forms and expands and then contracts when thawing. In far north areas with permafrost, water cannot drain into the soil and will accumulate in the top layer. When this freezes, the soil expands and can damage structures and storage ponds risking complete failure of the structure.

Many facilities use biological treatment to treat effluent. But biological treatments need to work in a narrow temperature range and will lose efficiency at colder temperatures. Cold temperature can also cause equipment failures as things like valves, pumps, and seals can be affected. Special low temperature lubricants need to be used. Burst pipes is a common problem.

If a pond is frozen and the drainage systems are blocked, it can be a big problem trying to figure out how to store and deal with effluent that is continuously flowing. Sometimes, you need temporary tanks or even totes as was the case for a landfill In Estonia that had approached New Logic a few years ago. The design of storage ponds in these climates is very risky and the best thing would be to not use them to avoid the risk of accidental release. VSEP membrane filtration and treat the effluent as it comes out and provide an option for ZLD and can eliminate the need for storage ponds.

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$100M Grants Available for Refurbishing U.S. Existing Coal Power Plants

In September of this year, the Department of Energy (DOE) announced that it would provide $625 million USD to help the coal industry to expand and meet the demand for power needed in the United States. In addition, on October 31st, the DOE has announced a Notice of Funding Opportunity (NOFO) to modernize and refurbish coal power plants in the country. The $100 million USD initiative will be provided to coal power plants to:

- Develop, engineer, and implement advanced wastewater treatment systems capable of water recovery for reuse.
- Investments in process changes allowing these plants to switch back and forth between coal and natural gas
- Deployment of systems that allow for co-firing of both natural gas and coal simultaneously

These investments will modernize coal plants to allow them to operate efficiently and affordably to provide more electrical power to the ever growing power grid. The DOE has stated that the U.S. is facing an urgent capacity crisis and its 2025 *Resource Adequacy Report* confirmed that the rapid retirement of coal plants has outpaced the deployment of new energy resources to replace them. In January, an executive order was issued directing the DOE to use its full authority to preserve and restore secure generation capacity.

The fact that some renewable energy sources have been intermittent, insufficient compensation for power in the markets, and "onerous" environmental compliance costs have forced many older power plants to run beyond the typical life cycle. The need for reliable power capacity is driven by surging national defense installations, new semiconductor manufacturing facilities and the explosion of Artificial Intelligence (AI) data centers. Coal fired

power plants have been an affordable and reliable source of power and can deliver near-term power at scale. They currently produce about 203 gigawatts (GW) of power and roughly half of that is an opportunity for strategic refurbishment that can widen the capacity gap that currently exists.

For the development of advanced wastewater treatment systems, the objective is to deploy proven, scalable, and cost effective treatment systems that can recycle clean water and are able to concentrate potential wastewater byproducts such as calcium sulfate (gypsum) for beneficial use. New Logic has supplied its VSEP equipment for 38 years to the power plant industry including coal fired power plants. Applications for VSEP have included cooling tower blowdown, fly ash leachate, and flue gas desulfurization (FGD) effluent. The EPA has named the VSEP as a best available technology for treating FGD effluent in its effluent limitations guidelines (ELG).New Logic has helped its power plant customer to keep pace with the new requirements and that has allowed many to stay in operation with the existing fuel source. The VSEP is able to treat the raw effluent without pretreatment and remove most of the volume as clean water filtration. The remaining brine concentrate is then sent to a small evaporator for a complete close loop solution.

VSEP Vibes Newsletter

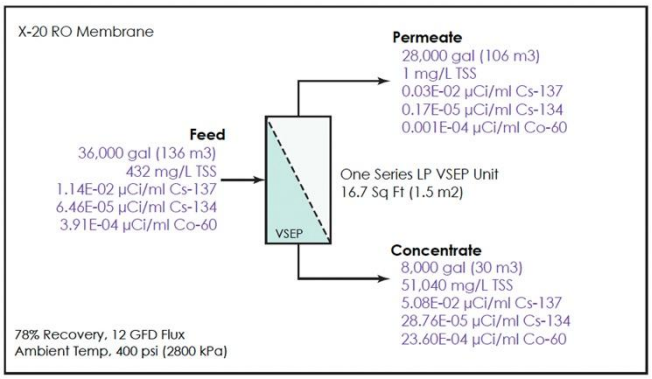
VSEP Does the Dirty Work at Rancho Seco

New Logic has done a lot of work in power plants of all kinds. VSEP systems have been installed at natural gas power plants to treat cooling tower blowdown. We have also installed systems at coal-fired power plants to treat scrubber water from exhaust flues. VSEP has also been used many times for radwaste at nuclear power plants. New Logic conducted simulation testing for the Peach Bottom Atomic Power plant in Pennsylvania, the Limerick Generating Station in Pennsylvania, and the Hope Creek Generating Station in New Jersey. We also completed onsite hot testing at the Kashiwazaki-Kariwa Power Plant in Niigata Prefecture in Japan. Most of the work VSEP has done on radwaste was for the decommissioning of the Rancho Seco Nuclear Power plant in California.

The Rancho Seco Nuclear Power Plant, located near Sacramento California, began operation in 1975. Three years later, a power supply device failed that feeds the instrumentation system. This led to a steam generator dryout and prompted an automatic reactor shut down. This was corrected and the plant was brought back online. The plant continued to operate until 1989 when it was closed by a public vote (53% to 47%) on continued operation. One of the issues was the increased electricity rates to finance the improvements to the plant.

The decommissioning work began in 1999. During the decommissioning process, equipment was washed and removed for disposal. This resulted in various poor quality waters that were segregated and stored. Some of the contaminated water was treated using conventional reverse osmosis (RO) membrane systems where possible.

Rancho Seco Decommissioning Wastewater



Effluents including the RO system reject, various sump wastewater, reactor cavity blowdown, and a boric acid sludge water were collected and were destined for evaporation via drum dryer. This became a very slow process. In 2001, a VSEP RO unit was brought in to pre-treat this radwaste water ahead of the drum dryer. The result was that the VSEP removed 80% of the water cutting the evaporation time in half. The VSEP permeate was sent to a demineralizing unit for further polishing and the VSEP concentrate was sent to the drum dryer.

New Logic has completed many other radioactive applications as well. We supplied equipment for a Uranium mine in Canada. We installed a VSEP system at the Molycorp rare earth mine in Southern California to clean up a spilled pipeline event containing Uranium. In the mining world, naturally occurring Uranium can be found in many places. But if you are doing earthwork and you move it, then you own it and have to report and subsequent discharge or even low radioactive materials. In Phosphate mining, Uranium is also found and will end up in the wastewater that is stored in large ponds known as Gyp Stacks. VSEP has been used for this treatment as well.

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VSEP Vibes Newsletter

The War Against Cows

Denmark has implemented the world's first tax on livestock flatulence. After 2030, farmers will have to pay a levy of $43/ton of methane produced from their operations. It is not clear how this will be measured. Dairy cow methane is targeted in many areas. New York State is considering limiting herd size. Even though the large amount of food that society wastes emits more methane when it decomposes than all dairies, the cow farmer is the one in the crosshairs.

A company, DSM-Firmenich has developed a feed additive called Bovaer which when added in small amounts to the cow's feed is said to reduce digestive methane production by 30-45%. The manufacturer claims that it has been fully tested and will not end up in the milk or meat of the animal. The product is approved for sale in 68 countries and has been mandated for use for all dairies in Denmark. However, changes in the way milk is produced is alarming many people. This is much as the use of antibiotics can cause concern. The cow's digestive system is the product of thousands of years of evolution. Meddling in the mechanism provided by mother nature is a little concerning. The UK's largest dairy cooperative announced that 30 of its farms will be using the product. This has caused many online debates to spread and people have been protesting by pouring out their milk or butter and boycotting certain products. Online video clips attacking the product have received 1.8 million views.

Bovaer is made using silicon dioxide, propylene glycol, and the compound 3-nitrooxypropanol (3-NOP) which is the enzyme inhibitor that reduces methane production. 3-NOP has a safety listing stating that it can cause skin and eye irritation and be harmful if inhaled. So People are naturally concerned, if it can be harmful to humans, how is it

OK to feed to cows. Bill Gates has been a long term critic of cow farts and another conspiracy theory is that he is behind this product. However, Bill Gates has started another company called Rumin8 that is developing a similar product.

While studies show that there are no effects on the milk or meat itself, it is not clear what impact the product has on the cow's sense of well-being. Denmark has mandated use of the product. The Danish Association of Milk Producers is reporting a lot of complaints from its members. They report that milk yields are lower. This association is even reporting that some members have said their cows collapsing and requiring treatment or even euthanization.

Enteric or digestive methane production accounts for 34.7% of methane produced at a dairy. 36.6% of methane produced comes from the manure itself. This can be recovered with an anaerobic digester. For a complete sustainable solution, VSEP RO can be used to treat the digestate after the biogas is recovered. The combination of biogas capture and VSEP produces clean water and nutrients and methane that can be sold as a product.

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VSEP Reduces Beverage Transportation Costs

Coconut milk is a stable oil in water emulsion where the proteins act as emulsifiers and thickening agents. Coconut milk is the liquid that is extracted by crushing and squeezing the white inner flesh of mature coconuts. A sweetened version is used to make the Pina Colada drink. Coconut milk is used as an ingredient in many traditional dishes in Latin America and Southeast Asia. The liquid found inside the coconut seed is called coconut water.

Coconut water is extracted from young green coconuts, where a hole is drilled into the shell to access the liquid inside. This is then filtered to remove suspended solids and packaged as a beverage product. This beverage can spoil quickly and must be kept cold right after processing. Shipping this can be difficult because it must be refrigerated. It is largely consumed in tropical regions near where the coconuts are cultivated. Thailand Indonesia, Philippines, and India are the largest consumers of this beverage and make up about 70% of the market consuming about a billion liters annually. Since the average yield from each coconut is about a half a liter, this is a very large operation.

Because transportation costs will be one of the most significant costs in bringing the beverage to market, efficiency is critical. It must be shipped in refrigerated transport vessels. This can use a lot of energy and takes up a lot of space. A client recently contacted a New Logic distributor about dewatering the Coconut water to volume reduce it to cut down on shipping costs. New Logic's distribution partner in China, Good Earth Agricultural, conducted pilot trials to determine the performance that is possible using VSEP.

A reverse osmosis membrane was used so that only water was removed and the sugar and electrolyte minerals are retained and concentrated. It is typically 95% water and contains glucose, fructose, and sucrose sugars. Coconut water also contains sodium, potassium, vitamin C, organic acids, and Cytokinin which has antioxidant properties. So retaining all the minerals and nutrients is important. Using 500 psi pressure (34 Bar), the VSEP RO membrane was able to remove 75% of the volume as water which represents a 75% reduction in hauling costs. The brix of the initial water was 4° and this was concentrated to 15.5° in the volume reduced liquid.

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Red Mud is Another Strategic Resource

Mining is all about separating one thing from another. It is not very often that pure metals or minerals are found in isolation. Most of the time these are harvested from an ore or brine and need to be removed and purified from a complex soup of various metals. For typical mining operations, there are established procedures and methods for this process. However, increasingly, critical minerals are found in places often thought of as waste streams. For example, rare earth elements (REE) can be found in abundant supplies in the tailing ponds from phosphate mines known as gypsum stacks due to the high concentration of calcium sulfate. REEs are also found in the combustion residue from burning coal known as fly ash. In addition, REEs are found in the residual effluent from Aluminum mining known as Red Mud. This is an effluent that is red because of the presence of iron oxide. It will also contain some aluminum and many other metals. New processes need to be developed to perform these new separations at a molecular level.

For this separation, pH can be used to preferentially separate materials. Iron and aluminum are the primary metals present that need to be removed and these also will have value once separated. At a pH between 3 and 4, iron will hydrolyze and precipitate as iron hydroxide. This can then be filtered using ultrafiltration. REEs are soluble in acidic conditions, so careful pH control must be used. Aluminum will precipitate as aluminum hydroxide at a slightly higher pH of 4.5 to 5. After iron and aluminum are removed, the REEs can be preferentially removed by solvent extraction using organophosphorus extractants which is already common in the rare earth mining industry.

Total heavy and light REEs found in red mud can reach 1000-2000 ppm making harvesting economically viable. Cerium can be as high as 600

ppm, followed by Lanthanum at 300 ppm, Neodymium at 250 ppm, and Praseodymium at 70. Trace amounts of Samarium, Europium, Yttrium, and other REEs can also be found. All of these mixed REE metals will preferentially be removed by solvent extraction at varying acidity levels.

VSEP has been used in many of these separation steps performing molecular separations. The advantage of membranes is that very precise size exclusions can be performed. VSEP has been used to remove and reject iron oxide, magnesium hydroxide, calcium sulfate, titanium dioxide and other conventional metals using ultrafiltration. When Nanofiltration is used with VSEP, acidic streams can be filtered to isolate monovalent and multivalent soluble minerals.

As the world looks for alternative sources of critical minerals such as REEs, new methods of separation will need to be developed. Also, as conventional ore deposits become depleted and harder to find, alternative sources of needed minerals will need to be exploited. There can be no better way than to take what is a waste product such as gypsum stack water, fly ash residue, or red mud and turn that in to a value added product that is easily accessible.

VSEP Vibes Newsletter

The Salty Truth about California's Water Crisis

The San Joaquin River flows north from southern California to the San Francisco Bay delta where it joins with the Sacramento river that comes down from the north starting at Mount Shasta. These two rivers are the drainage system for the state where snow melt, rainwater, and irrigation run-off leads to the Pacific Ocean. Salinity levels in the delta and these two rivers has been increasing. Salinity is carefully watched and forecasted by the State Regional Water Board. Limits are set for salinity and when needed fresh water from drinking water reservoirs like the New Melones Reservoir are released to the San Joaquin river simply to dilute the salinity.

There are 6.5 million acres of irrigated farmland in the central valley of California. There are also about 6.5 million people living throughout the valley. When farm land is irrigated some of the water evaporates and some percolates to aquifers. During this process, the salinity of the soil increases. Some water also runs off into local surface waters with increasing salinity. The public wastewater treatment plants treat the raw sewage and then it is discharged and will end up in the San Joaquin river. This is also adding dissolved solids (TDS) and salinity. Populations are increasing in this area. In addition to these, there are many food processing plants and other industries in the central valley that discharge wastewater also increasing the salinity of the rivers. This is a big problem and steps are being taken to limit TDS in industrial wastewater discharge.

45% of the south valley has salt affected soil. 30% of this had soil salinity of 8000 to 16000 µS conductivity. Limits for the San Joaquin River at Vernalis are 700µS. Fresh water from drinking water

supplies is released if this level is breached. In the north valley where the same issue exists in the Sacramento River, fresh water is deployed from Shasta, Folsom, and Oroville reservoirs to dilute the river.

Sewer discharge in inland areas is becoming more strict. Many facilities are required to be zero-liquid discharge (ZLD) or to meet very low levels of salinity in their discharge. New Logic has done several project like this in California where discharge is not allowed or it must be practically as good as drinking water. One of these was a power plant that had blowdown from its cooling towers. This was located in the south valley. VSEP RO was used before a crystallizer and an evaporator to be ZLD. Water that was recovered is sent back to the cooling tower. Another project was a large bottled water facility that wanted to get a permit to build a new facility east of Los Angeles. To get the permit, they were required to be ZLD because the brine reject from the spiral RO system could not be discharged. A VSEP RO system was installed to reduce the spiral reject from 20% to only 2% of the town water used for production.

VSEP Vibes Newsletter

Why New Beverage Launches Often Miss the Mark

Globally, more than 30,000 new food and beverage products hit the market each year—backed by significant investment and marketing campaigns. Like a blockbuster film, a new product launch is a gamble: success means revenue exceeds development and marketing costs, but failure can be costly.

There have been some notable beverage launch failures. In 1992, Pepsi launched CrystalPepsi which was a caffeine free cola. Despite heavy marketing, Crystal Pepsi captured just 1% market share in its first year, then quickly lost momentum and was discontinued within two years.. In 1985, Coca-Cola decided to change its formulation and launched NewCoke. Outrage ensued and the original formulation was restored after only 79 days.

Epic Cleantec, a San Francisco-based water recycling firm, has teamed up with Devil's Canyon Brewing to create beers brewed from purified residential shower water. The product is known a Shower Hour IPA. They have developed a 2nd beer product called Laundry Club Hölsch that is made using purified laundry wastewater. If you are brave enough and would like to purchase a few cans, here is the link: Shower Hour IPA

Epic Cleantec specializes in residential grey water recycling systems and has installed one of these at the Sales Force headquarters building in San Francisco. Purifying and recycling wastewater is not new and has been done for years, but generally, the reclaimed water is used for thing like golf course irrigation or industrial process water and not for human consumption. There are only a few cases where wastewater is purified and then directly reused. Water on the space station is continuously recycled. In Singapore, wastewater is purified and directly added back to the drinking water supply.

Beverage companies are leading the way in sustainability and often will use wastewater recycling internally to cut water use and waste generation. But this has not yet been done to make a drinking water product. Typically, RO membrane systems are used to treat wash water so it can be reused for process water needs in running the plant. For difficult effluents high in organics and suspended solids, advanced RO treatment systems such as the VSEP vibratory membrane system manufactured by New Logic Research is used. The VSEP system uses torsional oscillation of the membrane to prevent plugging and fouling of the membrane. This novel system has been used at many leading beverage companies to minimize the reject volume from conventional spiral RO membrane systems and separately to treat difficult effluents so that the water can be reused for cleaning and washing.

VSEP Vibes Newsletter

Keeping Data Cool

As the use of artificial intelligence and cloud storage programs proliferate, facilities that run servers to store this data and process information are getting larger. These facilities consume a huge amount of power and as this power is used, heat is generated. The recommended temperature at the server input is 64 to 80°F (18-27°C) To keep the electrical components from overheating, cooling is used. Initially standard air conditioning was used. But as the facilities got larger a more efficient means of cooling is needed. Water cooling circuits are used that consume a huge amount of water. The cool water enters the cooling loop and absorbs the heat and then this hot water evaporates to expel the heat. As this happens, the dissolved solids become more concentrated. These solids must be purged to prevent scaling of the system. This purge is known as cooling blowdown, The amount and frequency of this blowdown is calculated so that solubility or sparingly soluble salts is not exceeded. So this blowdown is often near the solubility limit of scaling compounds such as silica or calcium sulfate.

New Logic was contacted by an engineering company that is operating a large data center. They are seeking a solution for 400 gpm (90 m3/hr) of cooling tower blowdown. Many of these companies who own the data centers such as Microsoft, Amazon, or Google, aspire to sustainability and water use is a key factor. Additionally, disposal of concentrated brine can be problematic especially for inland locations.

The client sent a sample of the blowdown for bench testing at New Logic's testing facility. The initial sample had a conductivity of about 2000 µS and dissolved solids at about 920 mg/L. A test plan was set up to simulate a two stage VSEP RO

system. The primary stage of VSEP would recover most of the volume as clean water and then a second stage would concentrate the reject from the first stage.

After testing several RO membranes, the best one was selected and then a concentration study was completed. The primary stage VSEP recovered 82% of the volume as filtrate. This resulted in a 5000 mg/L TDS reject that was then fed to a second stage simulation. The second stage VSEP recovered 86% of the volume fed to it. The final reject had TDS of 30,000 mg/L. The overall recovery after two stages was 97%. The flux rates were very high - 81 GFD (138 LMH) in stage 1 and 45 gfd (76 LMH) in stage 2. For a ZLD solution a 12 gpm (3 m3/hr) evaporator could be added.

VSEP recovered 97% of the volume as RO permeate from this saturated brine. Due to the shear generated from the oscillation of the membrane and the resulting disruption of concentration polarization, VSEP was able to exceed the solubility limits and remove water without scaling. This water can be reused in the cooling system and offers a solution of zero discharge taking away that problem and liability.

VSEP Vibes Newsletter

VSEP Tackles Fungus Wastewater

Mushroom cultivation is an often forgotten industry but is a very important agribusiness. Mushrooms offer a wide range of beneficial essential vitamins and antioxidants promoting immune boosting properties and anti-inflammatory and anti-cancer properties. In 2013, the global demand for nutraceuticals reached 176 Billion USD with mushroom-based, products comprising 10% of this market. Total global mushroom production is estimated at 10 billion tons. Researchers have identified over 70,000 different species globally with about 2000 being edible and 10% being poisonous and a few being mortal. Industrial cultivation occurs in a grow facility. China produces about 76% of the world's supply of edible mushrooms. During the cultivation process a great deal of water is used for growing and processing the product.

Food safety is extremely important and growers adhere to very strict regulations concerning hygiene practices, pest control, and sanitation standards. This includes rules for hand washing, maintaining cleanliness, and controlling temperatures to prevent the growth of harmful bacteria and fungi.

The wastewater generated from processing operations that include the washing of the harvested product will have high levels of Nitrogen and Phosphorous. It can also contain high levels of chemical oxygen demand (COD) and bacteria. Sewer discharge of this water can be problematic and often growers will need to haul this effluent for treatment if they do not have their own treatment process.

Commercial cultivation of mushrooms can use 500-1500 Liters (130-390 gal) of water for each kg

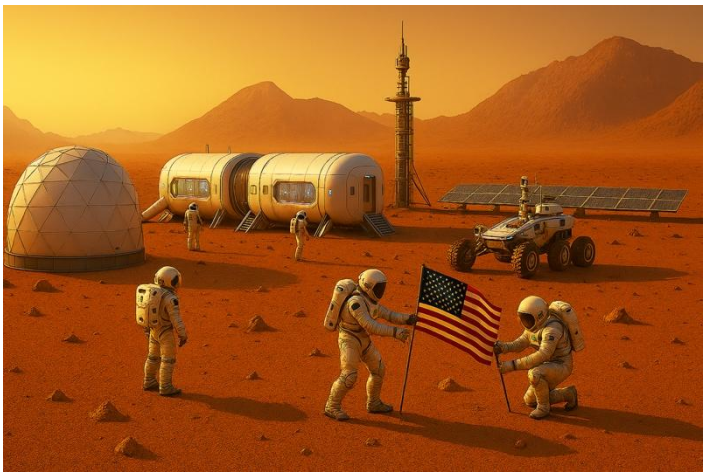
of mushroom product, Not very sustainable. Unlike normal farming on land, this water becomes a wastewater that must be treated. New Logic conducted a research study with a major commercial mushroom cultivation company to explore the use of VSEP to treat this wastewater and recycle the water to reduce operating costs. This client was hauling their effluent at the time. The test was performed over several weeks using a RO membrane. The VSEP was able to recover 80% of the volume as clean water for reuse. The remaining 20% concentrate would continue to be hauled. The VSEP achieved a throughput rate of 23 gallons per square foot per day (gfd)

The VSEP RO membrane system with only screening as pretreatment was able to produce water with non-detect levels of BOD, COD, suspended solids, and Phosphorous. Ammonia and total Nitrogen were reduced to less than 2 mg/L. As with many other food effluent recycling project, VSEP was shown to be effective at volume reducing the waste and supplying a clean water source that can be returned to the process.

VSEP Vibes Newsletter

Zero Liquid Discharge in Zero Gravity

The International Space Station (ISS) needs to be resupplied periodically and this can be expensive. Like food, water is essential. Not only is it used for hygiene and hydration, it is used to make oxygen. Exact numbers are not provided, but it is estimated that only 50-100 gallons of water is stored on the ISS. Every drop is carefully monitored and water is continuously recycled, even from sweat and humidity. If ever there was a case for absolute maximum recovery from wastewater and zero brine discharge it is here.



The ISS hosts 4-6 astronauts and each one is allowed one gallon per day for hydration and hygiene. No long showers here. So because only 4-6 gallons per day of water is recycled, a micro-scale recycling system is used. A Urine Processor Assembly (UPA) uses vacuum distillation to recover about 93% of the water from urine. The remaining brine goes to the Brine Processor Assembly (BPA). A special membrane is used that will not allow liquid or solids to pass but will allow water vapor to pass. Warm dry air is passed along the other side of this membrane and this becomes humid with water vapor which is then condensed and recovered allowing for an overall recovery of 98%. Another system is used to recycle hygiene water and humidity which involves microfiltration, activated carbon, ion exchange, and then disinfection. The 2% of the water that is not recovered needs to be resupplied along with other necessities periodically by cargo spacecraft such as the SpaceX Dragon. Since water is not only used for hydration, but also to make oxygen, there are contingencies for low supplies. These plans include limiting strenuous activities and adjusting dietary planning to use food requiring less hydration.

While this type is micro-recycling system can work for a few people on a space station that can be resupplied, something larger would be needed for planetary outposts on the Moon, Mars, or elsewhere. Transporting water to these locations would be a challenge.

20 years ago, Rutgers University, which has a VSEP pilot machine, prepared a study for the Advanced Life Support Office of the Johnson Space Center for NASA. This focused on advanced water recovery technologies for long duration space missions. NASA has widely studied membrane-based technologies because of the advantages. They can be compact, energy efficient, and do not involve a multistep process to make clean water. With no chemical addition other than periodic cleaning, the only other consumable is membrane replacement every several years.

The Rutgers study focused on the issue of concentration polarization and the limits of conventional membrane systems. Extreme high recovery would be needed to minimize the loss of water in the reject. Concentration polarization would limit this in most membrane systems and would introduce scaling potential of the membranes if the solubility limit is exceeded. The report also notes that space is a very unforgiving place and this puts a huge premium on reliability

and ease of maintenance for water recovery systems. The report also assessed the maturity of membrane technologies and their technology readiness level. It would be a unique situation in microgravity where there could be adverse effects from lack of surface tension.

The report looked at spiral RO membrane systems and noted that these cannot operate with suspended solids and the fact that the permeate must travel in a spiral flow to get from the underside of the membrane to the center core where it can be pushed out. In addition, concentration polarization would limit the recovery rates. Finally the report notes that the VSEP vibratory membrane can overcome concentration polarization and would limit fouling and would achieve very high recovery rates. It's a fun mental exercise to think about a VSEP in space. So far, we have not had a call from NASA, but we will see.

This Nasa report is no longer online, but if you would like a copy, just send me a note and I will send it to you if you like.

Thank you for subscribing to our newsletter. I hope you find it informational and fun. You are one of 3,200 professionals and industry stakeholders who receive this newsletter each month.

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January 2026 Newsletter Edition