VSEP Vibes Newsletter

Welcome to the New Logic Research Newsletter.

New PFAS Rules Coming for Landfill Leachate

In the year 2000, the EPA finalized the regulation for landfills that discharge their leachate directly to surface water. Landfills are like giant bathtubs. They start with a pit that is lined with plastic and then fill this with trash and finally cover it with earth when it has reached maximum capacity. The liner catches any moisture that settles to the bottom. This is called leachate. The moisture can come from the trash itself or from rainwater that trickles through the pile. Stormwater from the surface may also need to be captured and stored. The leachate is pumped out of the bottom of the pile and is stored on ponds until it can be disposed of. This water must be taken out of the trash pile, or like a bathtub it could overflow and could also cause the trash pile to become unstable and slip and fail. This has happened many times. Some recirculation of leachate can be done in some cases, but this alone will not solve the water balance problem.

In the United States, many landfills have made arrangements to transport their leachate to a local municipal sewage treatment plant. Requirements for direct discharge to surface water are pretty strict and this would require an onsite wastewater treatment plant prior to discharge. However discharge to the POTW tends to be less strict and really is a solution by dilution. The POTW may discharge huge volumes of treated sewage and the addition of a relatively small volume of potent leachate would be blended in. So the concentration of heavy metals and other pollutants would be small after dilution. However, there can be times when adding leachate at the POTW would mean that the POTW is not in compliance with its own discharge requirements and this option of discharge for leachate might not be allowed or could be revoked.

Mexico City Landfill

The EPA has recently noticed the dangers of a group of chemicals known as PFAS. These are forever chemicals that never decompose and can cause cancer. Because of their widespread use over many decades and the fact that they never decompose, PFAS is turning up everywhere. It can be found it groundwater and surface waters. Then these chemicals will go wherever the water goes. This could include irrigation water, drinking water, agriculture, industrial uses etc. So basically, these chemicals can be found almost anywhere, although perhaps at very low levels.

The EPA is now investigating eliminating the discharge of these chemicals from any facility that discharges a wastewater. PFAS is also found in trash and leachate can contain significant amounts. Conventional wastewater treatment methods will not remove these chemicals. Previously, the EPA had based its regulations for leachate on the use of biological activated sludge and multimedia filtration technologies. The previous methods of

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Sample	VSEP Feed	VSEP Permeate	Spiral RO Permeate	Discharge Limits
Total Dissolved Solids (mg/L)	4262	586	50	-
Total Suspended Solids (mg/L)	70	<1	<1	-
PFBA (ng/L)	2300	71	4	7000
PFBS (ng/L)	1200	36	0.3	100
PFHxA (ng/L)	4700	113	1	200
PFHxS (ng/L)	630	13	<0.2	9
PFOA (ng/L)	2200	34	1	4
PFOS (ng/L)	160	1	<0.1	4
PFNA (ng/L)	89	1	<0.2	10

treatment will not work now for PFAS. In January 2023, the EPA announced that it had completed a detailed study of landfills and have determined that new guidelines for treatment of leachate are warranted due to the presence of PFAS. The EPA is currently working on revising the previous regulation to make new requirements for discharge of leachate. This might also limit or prevent the use of POTW discharge. This could mean that any landfill in operation will need to install its own wastewater treatment plant that is capable of elimination of PFAS chemicals. These limits could be extremely low.

Membranes are uniquely able to reject PFAS. As mentioned in earlier newsletter articles, New Logic has installed two full-scale systems for PFAS remediation that have been in operation for many years. Not only can the VSEP membrane remove PFAS materials but it can do this from very difficult effluents like leachate. New Logic recently conducted extensive pilot testing at a landfill in the Midwest where the focus was on PFAS removal to extremely low levels. This landfill had concentrations of PFOA (one of the many PFAS chemicals) that were 2,200 ng/L. The stated limit for discharge is 4 ng/L. After one pass with the VSEP RO membrane, the PFOA concentration was reduced to 34 ng/L. Then with polishing using a conventional spiral RO, the level was reduced to 1 ng/L (Parts per biillion). The results showed that all seven of the PFAS chemicals were reduced and would meet the required low levels for discharge. In 3 of the 7 chemicals, the concentrations were non-detectable in the treated water.

These regulations will take time to develop and implement. Compliance with the new regulations would mean a massive change for landfill operations and a very large new expense for them. However, the good news is that VSEP is a viable technology that has been in used for many years for the treatment of leachate and so a solution does exist.

Resident of leachate pond on a VSEP Landfill Project

VSEP Coffee Extract Concentration

New Logic has recently installed its unique vibratory membrane filtration system known as VSEP to filter coffee extract prior to drying. The system is a two-module VSEP RO system installed in Europe about one year ago. This is the second system installed in Europe for this application. Energy savings is the justification for these installations. Rowan University in New Jersey recently conducted research using funds granted from the EPA to look at energy and cost savings when using VSEP RO to dewater the extracted coffee ahead of spray drying. The University concluded that operating costs primarily being energy costs could be reduced by 20% for a Nestle facility close by.

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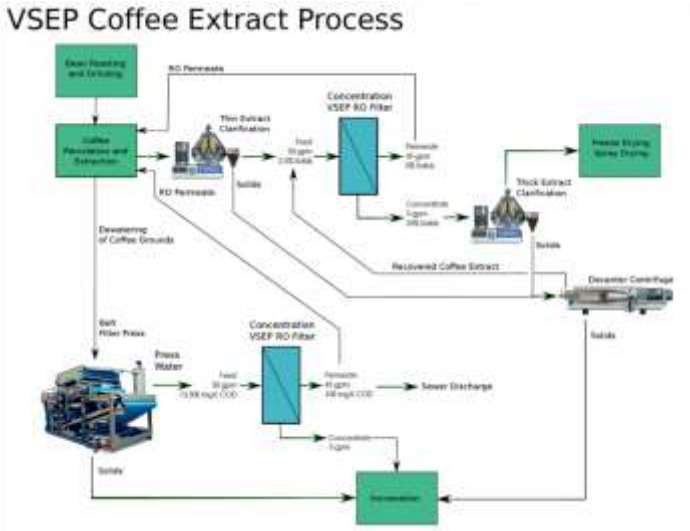
In addition to dewatering the coffee extract, there are a couple other places in the coffee drying process where VSEP can be used to reduce costs: 1] Treatment of the end of pipe wastewater - By doing this, BOD/COD surcharge fees can be reduced and heat and water can be recycled. 2] Recycle Caustic Wash Water – VSEP can be used with a high pH tolerant Nanofiltration membrane that would allow water and caustic to pass as filtrate and to reject COD, oil, color, and organics. The filtered caustic water can have COD as low as 200 mg/L.



Quoting from Rowan University's paper that was funded by the EPA:

"Nestle USA Freehold, NJ beverage factory, instant coffee production, involves thermal dewatering methods to produce soluble coffee powders. Coffee manufacture requires large amounts of energy and generates wastewater. Evaporation removes most of the water during production, and therefore is one of the most energy intensive steps."

"Using membranes as an alternative to, or in combination with evaporation, could address these problems of energy usage while retaining coffee powder qualities such as aroma and taste. The added benefit is that the membrane processes can recover water for reuse in factory operations, such as in cooling towers. Membranes have been used in previous food processing applications such a powdered milk production. One of the problems with membranes, however, is that the surface and pores foul after continuous use, reducing overall efficiency. Vibratory shear enhanced processing (VSEP) membrane systems mitigate this problem by using oscillatory vibration to create high shear at the membrane surface. This technology offers a promising area of research for more sustainable manufacturing" The system installed recently in Europe has been able to achieve about 90% recovery concentrating the coffee extract from 2% solids to about 20% solids. This means only 10% of the volume would need spray drying to make the final product.

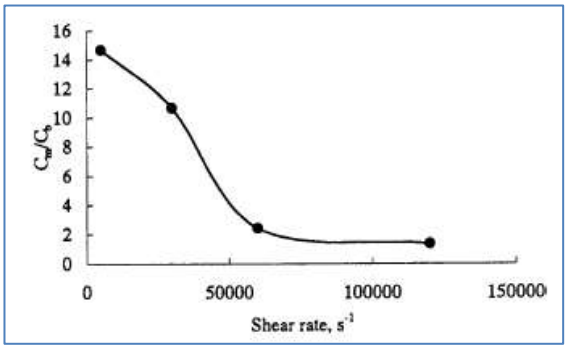
Shear Rate Formula

Shear Rate = speed of movement in meters/second ÷ membrane gap in meters squared

1" amplitude = 1.52 meters/second
½" amplitude – 0.751 meters/second

1/8" membrane gap = 0.003175 meters
0.003175 meters squared = 0.00001008062

Shear at ½" amplitude = 0.751 ÷ 0.00001008062 = 74,500 s^{-1} (inverse seconds)



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VSEP, How it all Started

Dr. Brad Culkin, one of the founders of the company and is also the inventor of the VSEP technology. Brad earned his BS in Chemical Engineering from the University of Pennsylvania and his Masters Degree from John Hopkins University in Maryland. Finally Brad earned his Ph.D. from Northwestern University in Chicago with a dissertation on Rivulet Meandering. A rivulet is a small stream and the presentation described the forces at work that caused the path of the stream to change course and meander.

Dr. Brad Culkin working on an early version of VSEP

Brad then worked for Dorr-Oliver, a filtration company, and was promoted to senior scientist in less than 2 years. He headed a research team developing a colloid mobility measuring instrument and developed a separation technology using

The first VSEP was a table top device

electrophoretics in combination with Ultrafiltration to dewater a colloidal suspension. Brad cofounded Velodyne Associates where he developed servo-controlled loudspeakers.

The 1980s was the time in the San Francisco Bay Area when Silicon Valley was getting going. Things were a little more tame than the 1970s which was filled with Love-Ins and anti-war protests in the Haight-Ashbury district. IBM was already there. Hewlett Packard was two guys in a garage. During this time, Brad met up with Ric Johnson who was fresh out of college after attending the University of

Nevada at Las Vegas. Ric achieved a business degree. The two of them became friends and started thinking about ways they could work together. It was a perfect match. Through acquaintances, they came to know the guy who invented the CD disk who had become very wealthy. Ric and Brad decided to go the invention route and see what they could produce.

Ideas were always no problem for Brad and he had many ideas about products that could be improved or created. The trouble was deciding which one to go for. Brad had prior experience with Membranes at Dorr-Oliver and the two of them came across an opportunity where a pharmaceutical company was looking for a table top blood separation device. Ric, using his business advocacy skills approached them and negotiated a contract to build and design a vibrating desktop ultrafilter that could separate blood plasma. The device was then created by Brad and then demonstrated by the both of them to the pharmaceutical company. They retained the intellectual property rights to the invention.

That was the start of it all. Using the funds received from that project, they decided to start a filtration company in 1987. Now the task was to scale up so that the equipment could be used for many purposes from small to big. This was a big challenge, but they were not deterred. During the early deign, one of the things tried was to use a coil spring from a Mazda car as the torsion spring. A prototype was built and when they started it, it hopped across the floor like a helicopter that just quite could not take off. Several iterations later, they settled on the current solid steel torsion spring with a heavy mass on the bottom and the filter mass on the top of the spring. Many difficulties ensued. Being young and having no fear, they continued. The first larger VSEP machine was similar in size to our current P-50.

After the basics of the design were hammered out, development of even larger sizes happened. During the early 1990s many deign improvements were develop to correct design flaws. Now 35 years later, the technology is very mature and has been in use at hundreds of locations around the world.

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Baby VSEP Machine – Series B

We did a trade show one time and had set up a LP VSEP in our booth with some simulated feed. It is a machine with a pump and so you can hear it. People could not help but stop and look at it, not only because it made a sound but because it was moving. People really understand the power of the vibration effect when they first see a VSEP in operation. Well, even though the LP was not all that loud, our neighbors in the next booth did not appreciate all the attention our machine was getting.

Later, we designed a very small and quiet VSEP demonstration machine called the Series B. It operates on e110v or 220v single phase power and can be plugged in anywhere there is a standard outlet. It uses about 12 amps of current. It is easy to set up. It has a 6" diameter piece of membrane and the vibration resonance is the same as what you see in larger VSEP machines. It is so quiet that it is hard to tell it is running. So now we have a very good demonstration machine that can be used at your office or at trade shows to show to potential clients how the resonance is created and what the vibration looks like.

It is a very small piece of membrane and is not designed to be used as a pilot machine. Any operating data collected would not be representative of what the larger VSEP would produce. We use it with a three-cell acrylic tank so that the dirty feed water is taken from the center and the dirty reject is deposited back to one cell and the clean permeate is sent to another cell for a visual demonstration of the separation.

Digester Effluent VSEP Commissioning in Valencia

New Logic has installed its 33rd biogas effluent treatment project, this time in Valencia Spain. There are thousands of biogas plants and people have struggled for years to deal with the effluent. This often gets little attention when the project is first developed. The investors will focus on how much methane gas can be made and what they can sell this for and how much they can get in subsidies. But the economic viability of these plants can be very difficult. Many of the 33 projects that New Logic has installed have shut down for various reasons including neighbor complaints and rescinding of government subsidies.

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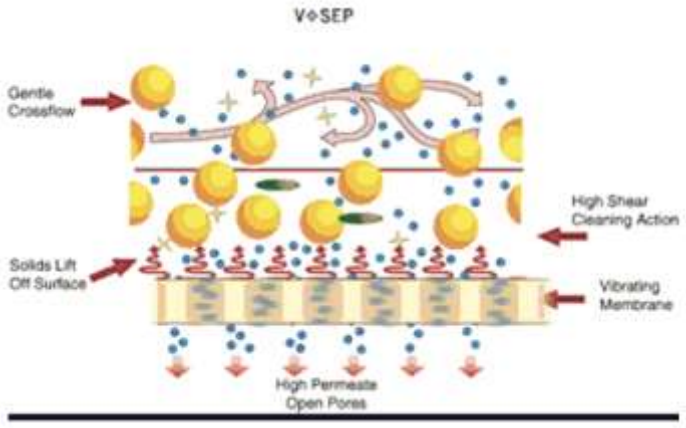
The organic substance feeding these digesters can be pig manure, cow manure, food waste, or other organic materials that are high in volatile solids. Methane gas is produced in the anaerobic digester. Carbon Dioxide is also produced and must be separated from the methane and then captured

Our project in Spain was accomplished by our distributor Sitra. The project involves a two-module VSEP RO system. At the time of commissioning, the system was operated at 50% recovery with about 3.4 m3/hr (15 gpm) of permeate at 20 Bar pressure and 35°C temperature. Pre-treatment to the VSEP included a 25 µm MF filter to remove large solids. Sitra had completed extensive pilot testing with 28 batch concentration studies. These showed recovery rates of between 40 and 60%. The results during commissioning of the full-scale system matched the results obtained during the initial pilot testing.

The company operating the biogas plant takes manure from surrounding farms. The objective for the VSEP system was to reduce the volume of the effluent so the concentrate can be used as a fertilizer product.

How VSEP Works

New Logic has developed an alternative method for producing intense shear waves on the face of the membrane leaf element. The technique is called Vibratory Shear Enhanced Processing (VSEP). In VSEP systems, the feed slurry remains nearly stationary, moving in a leisurely meandering flow between parallel membrane leaf elements. The leaf elements move in a vigorous vibratory motion tangent to the face of the membranes. The shear waves produced by the membrane vibrations cause solids and foulants to be repelled and liquid to flow through the membrane pores unhindered.



In an industrial VSEP machine, the leaf elements are arrayed as parallel discs separated by spacers. The disc stack is moved in a torsional oscillation, like the agitator of a washing machine, faster than can be seen without a strobe light. This produces a shear rate at the membranes of about 75,000 inverse seconds, literally ten times greater than that obtainable in cross flow systems. In contrast to cross flow systems where as little as 10% of the energy required to run the system is converted to shear, VSEP enables nearly 99% of the total energy to be converted to shear at the membrane surface where it can do the most good.

Extremely high shear is accomplished by the torsional vibration of membrane disks in a resonant spring mass system. The membranes, which are attached to this plate, move at an amplitude of 5-10 degrees and a frequency in the range of 50 Hz. The fluid in the filter pack moves slowly through the pack in a serpentine fashion parallel to the membrane trays. The motion of the filter pack

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creates a highly focused shear zone at the wall (membrane surface). Retained solids at the membrane surface are effectively removed by the shear, allowing for higher pressures and higher permeate rates.

VSEP is simply two masses connected by a torsional spring, which is excited at its natural resonant frequency. One mass (the Filter Pack) is lighter, holds the membranes, and moves with high amplitude. The other mass, the heavier Seismic Mass, moves with smaller amplitude proportional to the ratio of the two masses. The use of two counter-rotating masses allows the system to resonate without attachment of the device to a rigid surface.

The VSEP torsion spring is designed for infinite life. New Logic has shipped about 300 systems around the world and in these 300 systems, more than 2000 VSEP torsion springs have been deployed. This started about 35 years ago.

People often look at the torsion spring in operation and are amazed by the ability of the steel bar to move that much that quickly. They find it hard to believe it is possible. Many that see this might assume incorrectly that it cannot be possible for this to happen day after day and week after week. The fact is, this is basic engineering. Any mechanical engineer learns these principles and understands the dynamics and the properties of steel. Determining the strength properties of steel and calculating the load stress applied is a simple matter of a couple of mathematics formula.

The torsion spring is really the key design feature of the VSEP machine and is the core of the patented technology. The beauty of VSEP is that it looks very simple and yet is very complex and highly engineered.

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