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Local startup uses bacteria to clean water

Aquacycl using novel process to treat brewery wastewater in Joshua Tree

By Mark Armao
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When avid homebrewer Dario Guerra and a handful of friends decided to open a microbrewery in the small town of Joshua Tree four years ago, they figured all they had to do was chip in some cash and start working on recipes. “We all got together one day and decided we’d take our hobby from a garage and step it up to a building,” Guerra said. “But it’s a lot easier said than done.”

San Bernardino County officials told them that, because the town does not have a sewer system and lies above an aquifer, the brewers would have to find a way to treat the wastewater that would be discharged by the facility before they could open their brewhouse. “We came to an extreme halt when we learned that starting a brewery is not an easy project in regards to wastewater,” said Guerra, who works as an engineering technician at the Marine Corps base in the nearby town of Twentynine Palms. The team began searching for a commercial-grade treatment system, but soon discovered that their low initial output meant there were no “off the shelf” solutions in their price range, he said.

Enter Aquacycl, a treatment system developed in San Diego that uses bacteria to treat industrial wastewater while producing electricity in the process. Guerra said the cost of the novel system, which the company offers under a leasing plan, was about half the price of conventional treatment technologies. Building on research she conducted at the University of Southern California, Aquacycl founder and CEO Orianna Bretschger developed the technology at the J. Craig Venter Institute in La Jolla.

She spun the company out of the institute in 2016, and has since installed two pilot systems: one that treats wastewater from a pig farm at San Pasqual High School in Escondido and another that cleans sewage at an eco-friendly park in Tijuana. Using a recently secured grant from the federal government and several Southwestern water agencies, Aquacycl will partner with BioLargo, a Santa Ana-based water technology company, to treat wastewater from the brewery to the point it can be used for landscape irrigation. “When you brew, you’re after the beer, but there’s a lot of waste product that comes out,” Bretschger said. “It’s not pathogenic, nasty waste, but it’s still a lot of stuff to get rid of from the water.”



Courtesy of Aquacycl

The bioelectrochemical treatment technology (BETT) uses a special type of bacteria to treat industrial wastewater while producing electricity. At San Pasqual High School in Escondido, the system treats 150 gallons of pig waste per day.

To ensure the untreated effluent does not reach the underlying aquifer, Bretschger’s team will install an on-site treatment system for Joshua Tree Brewery, which Guerra hopes to open in October.

“That’s our goal,” Guerra said. “We’ve been doing this so long, but there’s finally a light at the end of the tunnel.”

Beery bacteria

The Aquacycl system is called the bioelectrochemical treatment technology (BETT), which is based on microbial fuel cell technology. As opposed to conventional forms of water treatment technology — which usually process wastewater by injecting oxygen and require the installation of expensive infrastructure — the BETT system does not require major construction and treats the drainage anaerobically, or without forced oxygen. “It’s a plug-and-play, modular solution for doing anaerobic treatment on site, which helps our customers with their disposal costs, removes the contaminants and produces electricity,” Bretschger said.

The treatment process occurs inside bio-reactors that are stacked “like Legos” inside a 20-foot shipping container, she said. The team places locally sourced bacteria inside the reactor,

where the microorganisms form a biofilm on its interior surfaces. As the bacteria break down the carbon-based organic matter in the wastewater, they grab electrons that they use in the process of respiration. The type of bacteria selected by the team respire, or breathe, in a way that’s similar to human cells — with a few major distinctions, Bretschger said.

She explained that the microbes have “figured out” how to breathe without oxygen and how to move electrons from the inside of the cell to the outside. Once the electron reaches the outer surface of the cell, the system captures it.

“When the bacteria touches something conductive, it discharges,” Bretschger said. “So, when the microbe is attached to the surfaces in our reactor, they’re constantly discharging electrons, which are then harnessed by us, and we move them across a circuit to produce direct electricity. “And the bacteria stick around doing this because they get to breathe.” By harnessing the electrons leaving the bacteria, the system generates enough electricity to power itself. Bretschger said the electricity generation capability is exciting, but that the “really cool thing” about the technology is that increasing the rate that electrons are taken away speeds up the treatment rate.

“It not only accelerates their carbon metabolism, but it also means that they can’t use that energy to grow any more of themselves,” she said. “So they don’t overgrow, they don’t foul the system, and we’re not producing a lot of extra sludge, which is usually a problem in conventional wastewater treatment systems.”

Pesky molecules

Although the water that comes out of the BETT system has far less organic material than it contained originally, there was still a problem for the brewery: nitrates. The nitrogen compound, which can be harmful to humans, occurs naturally but its introduction to the environment through sewage or agricultural fertilizers can cause high concentrations to seep into the water table. To protect the Joshua Tree groundwater sub-basin — a three-tiered aquifer under 2,000 feet of sand and gravel — the Joshua Basin Water District caps the allowable level of total nitrogen in wastewater discharge to 10 milligrams per liter.

“The [water district] loved the



Mark Armao/The Daily Transcript

A San Diego-based startup plans to install an advanced water-treatment system at a proposed brewery near Joshua Tree National Park, pictured here.

team will test the discharge from Guerra’s small batches starting in August, and will optimize the components over the following months before building out the full system next year, Bretschger said. “We’ll get everything dialed in between the two systems — really get it cranking — and then, when he’s ready to go full capacity, we can scale very quickly and easily without a lot of troubleshooting,” she said.

and a bicycle-shop owner.

“The idea was that our beer is half-way decent,” Guerra said, explaining the team’s decision to start a micro-brewery. But the description seems to be an understatement; their beers have won medals in both local and national homebrewing competitions. Guerra said one of his most well-received recipes is a Belgian strong ale known as “Scary Gary,” which was named after a beer drinker who tended to “go off the deep end” when he imbibed the high-alcohol ale. Using both new and established recipes, the brewery will pour pints and fill aluminum growlers in the tasting room, but will “stay away” from glass bottles because of the building’s proximity to Joshua Tree National Park, Guerra said. Operating in a small commercial building three blocks from the visitor center, the company hopes to tap into the tourist market while retaining a local vibe, Guerra said. The team also plans on collaborating with other homebrewers in the area to cultivate an inclusive lineup of local beers. “We get a lot of traffic from the park so I think it’s a perfect way to have a unique experience in which visitors come to the park and have a casual drink that’s crafted by members of the community,” said Jessica Rudd, co-owner and business manager of the brewery. Despite the perceived need for a brewery in Joshua Tree, the brewers don’t plan on quitting their day jobs. “I’ve got two kids I’ve got to put through school so I can’t depend on this brewery to be the Stone brewery of the high desert,” Guerra said. “But who knows? The sky’s the limit if it’s welcomed and it’s a success.”

And while the fledgling company has lofty aspirations, the brewery

could not target an October opening without the help of Aquacycl, Guerra said. “Orianna and her company have been hitting home runs for us,” he said.

Rock-breathing microbes

A roundabout course led Bretschger to the bioelectrochemical water-treatment industry. After studying physics as an undergrad, the Arizona native went to the University of Southern California to get a PhD in engineering. She attended a talk at USC by Kenneth Nealson, a biology professor who did not realize he would soon become her graduate advisor. “He gave this amazing talk about how bacteria can produce electricity and how they breathe rocks,” she said. “I begged him to take me as a student even though I’d never had a biology class before.” By the time she arrived at the Venter Institute, she was already researching ways to harness the unique properties of bacteria to treat water. She published more than 40 research papers alongside her team at the institute before embarking on her own venture with a handful of colleagues.

While Aquacycl has installed two pilot systems in the San Diego region, the brewery is the company’s first commercial customer. Bretschger, who has dabbled in beer-making in the past, said the company is in talks with a few large local breweries, which are sometimes forced to build treatment plants in areas that have sewers but lack the necessary capacity. “It’s an interesting opportunity for us, and a way that we hope we can support the craft brew industry in California and beyond,” she said. She also envisions the technology being used on farms, to treat manure, and by the military, at forward operating bases.

Ultimately, Bretschger would like to see the system used in emerging markets to “provide sanitation to communities that need it the most,” she said, noting that that roughly 2.5 billion people do not have access to toilet facilities, and 80 percent of all wastewater generated globally is discharged directly to the environment with little or no treatment. “This has devastating impacts on the environment and human health,” she said. “With a system like ours — which is modular, cheap, scalable and can work without a sewer grid or an energy grid — we have an opportunity to change the game.”

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Orianna Bretschger, Aquacycl founder and CEO



system, but the problem was the nitrogen,” Guerra said. “The levels were a little too high, so that’s how we ended up dealing with BioLargo.” The publicly traded company develops an array of water treatment systems, two of which will be used in Joshua Tree. Outflow from the Aquacycl system will first go through a denitrification system developed by BioLargo, Bretschger said. The effluent will then pass through BioLargo’s Advanced Oxidation System, which will disinfect the water to the point it can be used to irrigate plants at the brewery.

“We’re out here in the desert,” Guerra said. “We can use all the water we can get.” Using a \$50,000 grant from the U.S. Bureau of Reclamation, the Metropolitan Water District of Southern California and several other water agencies, Aquacycl and BioLargo will install a scaled-down version of the system in Joshua Tree. The

Beer desert

Despite the enthusiasm of Joshua Tree’s homebrewing community, the craft beer scene in the area has not matured at the same rate as brewpub hubs like San Diego. “There is no craft brew scene,” Guerra said. “There are two restaurants and a bar up here but the nearest microbrewery is [in the Palm Springs area], 50 miles away.”

To bring locally brewed ales and lagers to the 10,000-person town, the owners of Joshua Tree Brewery plan to open a 2,600-square-foot space with a seven-barrel (210 gallon) brewhouse and an 800-square-foot tasting room. Guerra, who will serve as CEO and head brewer, said the brewery will initially offer a range of styles, from crisp lagers to malty porters and hop-forward IPAs. Brewing in his garage, many of the recipes were concocted alongside the other members of the five-person partnership, which includes a doctor