Squeezing every last drop out of wastewater

Partnering with Nestlé, ASU is working to reduce the amount of briny waste left over from water desalination

By Faith Kearns, ASU News
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Industries that need ultra-pure water — including semiconductor, battery, pharmaceutical, food and beverage companies — are expanding in Arizona. One of the most overlooked challenges for these businesses is what gets left behind in the pursuit of clean water: brine, the salty byproduct of processes like reverse osmosis.

However, for Shahnawaz Sinha, an associate research professor in civil and environmental engineering at Arizona State University, brine isn't just waste, it's an opportunity. Through a partnership with Nestlé and supported by ASU's Arizona Water Innovation Initiative and the Global Center for Water Technology, Sinha is developing a mobile, closed-loop water recovery demonstration facility that could change how industries in the metro Phoenix area deal with brine.

By recovering another 50%–90% of previously unusable water from industrial brine and reducing the remainder to solid salt, the project aims to minimize waste and extract freshwater to support Arizona's economy and water resilience.

Sinha brings decades of experience to the table. Before joining ASU nearly 10 years ago, he spent six years at the Water Desalination and Reuse Center at King Abdullah University of Science and Technology in Saudi Arabia, a country heavily reliant on seawater desalination. Prior to his time there, he spent nearly a decade as a process engineer at two different environmental consulting and engineering firms.

"Brine is a critical component and byproduct of desalination," Sinha said. "In Saudi Arabia, they can discharge it into the sea, but inland places like Arizona don't have that luxury."

Arizona's salty reality

Increased salinity in freshwater is a growing issue across the country, and while the Phoenix metro area doesn't have to deal with road salting during winter weather and isn't desalinating seawater, it still faces serious salinity challenges.

"I lived in Colorado for many years, and the water is fantastic. But that same Colorado River water becomes much saltier by the time it reaches Arizona," Sinha said.

As water from the Colorado River travels through the arid landscapes and open canals of Arizona, salts become more concentrated due to evaporation.

Like many Arizona residents, Sinha said, “I do have a small reverse osmosis, or RO, system under the sink at home to improve its taste so I can drink this water more easily.”

In addition, the Valley sits on naturally salty ground. For example, the Hohokam built extensive canals and encountered salty soils that created challenging farming conditions. In addition, the Luke Salt Body west of Phoenix is estimated to be 10,000 feet thick and 40 square miles across. And the aptly named Salt River and its tributaries flow through salt deposits across the state that eventually end up downstream in the Valley.

The salt remains in the Phoenix region’s drinking water, which is the same water that manufacturers use as their starting point. At each manufacturing facility, the company “desalinates” tap water on-site, producing ultra-pure water for industrial use and leaving behind salty brine.

For example, a Nestlé plant requires high-quality water for product quality and food safety, and any salt content could compromise the taste or stability of the product. Chipmakers, including TSMC and Intel, face even stricter demands, as microscopic salt or mineral residues can damage wafers or disrupt sensitive manufacturing processes.

The resulting concentrated brines must be carefully managed and disposed of. While some sewer systems can accept brine, many facilities must resort to evaporation ponds or off-site trucking. Brine disposed into sewers flows to wastewater treatment plants, where high salinity levels can increase the cost of desalination or negatively impact the reuse of treated water for irrigation, such as on grass and other vegetation.

“The Phoenix area is a salt concentrator,” said Paul Westerhoff, Regents Professor at ASU and director of the Global Center for Water Technology. “It's not just, well, let's take out the salt. Once you take it out, where does the salt go? We are one big salt accumulator here. A two-part study by the Bureau of Reclamation showed more than $30 million a year in economic damage from salt. This means that innovative ways of dealing with brine are crucial for water security and a thriving Arizona economy.”

Industry collaboration

Nestlé’s Arizona production facility generates more than 50,000 gallons of brine every day, so much that multiple tanker trucks must haul it off-site, daily.

“It’s becoming very expensive for Nestlé to tackle this brine issue,” Sinha said.

Rather than see it as a problem, Nestlé saw an opportunity and turned to ASU for help.

“They opened up to us and said, ‘We have this brine issue. What kind of research can you do to help us minimize it?’ We really appreciate how open they are because they are not the only ones facing this issue,” Sinha said.

His team began by analyzing the brine.

“I was expecting the water would be turbid with lots of particles in it,” Sinha said. “But it was nice and clear; it just had a lot of salt.”

As the brine is progressively concentrated through treatment, the appearance changes.

“Just like if you put salty water in a pot and boil it down, the water becomes whitish and thicker. That’s exactly what happens as we push water out of the brine and increase its salinity.”

The team’s approach uses a multi-step system that includes pretreating Nestlé’s brine to remove larger particles and make it more amenable for further treatment. It then moves through a reverse osmosis process that separates the liquid into two streams: high-quality water for reuse and a salty concentrate.

The salty concentrate then passes through a hydrophobic membrane to recover even more pure water. The highly concentrated brine is sent through a dryer and a crystallizer to reduce the brine to a solid salt product. Atmospheric water harvesters can then be used to capture any remaining water vapor.

“The goal is to recover 50%–90% of the water,” Sinha said, “and end up with a manageable volume of crystallized salt.”

While questions remain about how best to reuse or dispose of the salt, this method drastically reduces the burden on trucks and wastewater plants.

Sinha said one of the most exciting aspects of the project is the collaboration itself.

“Nestlé has very skilled engineers and water plant operators. We meet biweekly. They tell us they benefit because we interpret the data in different ways and bring fresh insight.”

Nestlé recommended building a broader coalition of manufacturers facing similar brine challenges in the west Phoenix region, which led to a unique gathering. In May, the Global Center for Water Technology and the NSF Futures Engine in the Southwest convened manufacturers, water providers, technology developers and researchers to better understand these brine-related issues. Together, they are developing a roadmap to reduce brine management as a barrier to economic development.

During a recent presentation, Nestlé staff applauded the partnership, noting that benefits for them include testing innovative approaches to water stewardship, as well as access to expert knowledge at ASU and workforce development.

“We’re working to involve nearby community college students to gain hands-on experience, in part because the plant is in the (far) West Valley, pretty far from campus,” said Sinha, “so they can see how ASU works with industry. It could also serve as a training ground for aspiring students and Nestlé operators.”

Looking ahead: Turning waste into opportunity

Sinha said this project is part of a larger shift in how we think about water, waste and resource recovery.

“Sometimes we engineers get caught up in how much water we can recover,” Sinha said. “But there’s also potential opportunity on how to sustainably manage the waste and extract commercially viable mineral salts, valuable elements like lithium, magnesium or potassium from concentrated brine. That’s where innovation meets impact.”

While the technologies are currently expensive, industry seems ready to invest.

“Nestlé is thinking not just about their own plant, but about others moving into the area. They’re leading by example,” Sinha said.

In a region where water is critical and salt never really disappears, finding sustainable ways to close the loop is both a scientific challenge and an economic necessity.

As Sinha put it: “No drop of water should be wasted.”

Why this research matters

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This story originally appeared on ASU News.

Main image

The MacroTechnology Works ultra-pure water facility. Photo courtesy of the Global Center for Water Technology

Text image(s)

The Verde Valley once was home to a lake that formed rock salt deposits. The Verde River, a tributary to the Salt River, carries salty water into the Phoenix metro area. Photo courtesy of Lee Allison/University of Arizona/Arizona Geological Survey

MacroTechnology Works' ultra-pure water facility shows the scale and types of systems needed to treat brine. Photo courtesy of the Global Center for Water Technology