Researchers achieve major breakthrough with water desalination system

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(PhysOrg.com) -- Concern over access to clean water is no longer just an issue for the developing world, as California faces its worst drought in recorded history. According to state's Department of Water Resources, supplies in major reservoirs and many groundwater basins are well below average. Court-ordered restrictions on water deliveries have reduced supplies from the two largest water systems, and an outdated statewide water system can't keep up with population growth.

With these critical issues looming large, researchers at the UCLA Henry Samueli School of Engineering and Applied Science are working hard to help alleviate the state's water deficit with their new mini-mobile-modular (M3) "smart" water desalination and filtration system.

In designing and constructing new desalination plants, creating and testing pilot facilities is one of the most expensive and time-consuming steps. Traditionally, small yet very expensive stationary pilot plants are constructed to determine the feasibility of using available water as a source for a large-scale desalination plant. The M3 system helps cut both costs and time.

"Our M3 water desalination system provides an all-in-one mobile testing plant that can be used to test almost any water source," said Alex Bartman, a graduate student on the M3 team who helped to design the sensor networks and data acquisition computer hardware in the system. "The advantages of this type of system are that it can cut costs, and because it is mobile, only one M3 system needs to be built to test multiple sources. Also, it will give an extensive amount of information that can be used to design the larger-scale desalination plant."

The M3 demonstrated its effectiveness in a recent field study in the San Joaquin Valley in which it desalted agricultural drainage water that was nearly saturated with calcium sulfate salts, accomplishing this with just one reverse osmosis (RO) stage.

"In this specific field study by our team, in the first part of the reverse osmosis process, 65 percent of the water that was fed in was recovered as drinking water, or potable water," said Yoram Cohen, professor of chemical and biomolecular engineering and lead investigator on the team. "We can potentially go up to 95 percent recovery using an accelerated chemical demineralization process that was also developed here at UCLA. This first field study with the M3 was a major achievement and the first phase of our high-recovery RO process demonstration program."

Andi Rahardianto, a postdoctoral researcher on the team, said that the approach taken by the group is "a significant leap" from the standard practice in the industry of constructing different pilot plants, often from scratch, in order to evaluate and demonstrate the feasibility of water production from different source waters.

"We believe systems such as the M3 can help accelerate not only water technology development but also its adoption," he said.

In addition to its use as a pilot-scale testing unit, the M3, according to Bartman, could also be deployed to various locations and used to produce fresh water in emergency situations.

"The M3's 'smart' nature means it can autonomously adapt to almost any variation in source water, allowing the M3 system to operate in situations where traditional RO desalination systems would fail almost immediately," he said.

Though the system is compact enough to be transported anywhere in the back of a van, it can generate 6,000 gallons of drinking water per day from the sea or 8,000 to 9,000 gallons per day from brackish groundwater. By Cohen's estimate, that means producing enough drinking water daily for up to 6,000 to 12,000 people.

"The system measures in real-time water pH, temperature, turbidity and salinity," said Cohen, who is also the director of UCLA's Water Technology Research (WaTeR) Center, which is overseeing this project. "It can control a variety of process variables, including the precise measure of chemical additives to condition the water. All the valves are computer-controlled, so the system can adjust itself automatically. We can also see how much energy we're using, and in the software, we've also included various techniques for optimizing the system so that it can run with minimum energy consumption."

"The last time UCLA went into the field with its own newly built pilot system was in the '60s," Cohen said. "This new system is one-twentieth the size of what was built then, maybe even smaller, and can produce up to 30 percent more potable water. So to actually go back to the San Joaquin Valley with new advanced technology and be successful is quite an event."

Rahardianto said that the highly saline agricultural drainage wastewater in the San Joaquin Valley is one of the most difficult source waters to desalt.

"It has been a persistent issue for communities in the valley, one of California's most productive agricultural regions," he said. "While numerous attempts have been made to develop and test various desalting technologies since the 1960s, a practical, cost-effective solution has not yet been adopted, increasingly affecting the ability to sustain agricultural productivity in the region."

Cohen's team is working with water agencies and industries across the United States, as well as with the international community, and collaborates with research institutions such as Ben Gurion University in Israel, Victoria University in Australia and Tarragona University in Spain.

According to Stephen Gray, director of the Institute for Sustainability and Innovation at Victoria University, "the M3 system is a very significant improvement in desalination operations, allowing the membrane systems to effectively and quickly adapt to changes in water quality and to achieve high water recoveries. Such advances are of great importance to Australia and many other places in the world, where many communities are facing shortages in fresh water supplies and are becoming more reliant on saline water sources."

"We envision a future where many of these systems are deployed all around the world and their operation monitored from a central location," Bartman said. "The M3 could be used to rapidly test water sources so that desalination plants can be constructed to augment the diminishing fresh water supply. The system could also be used in the event of emergencies to provide a quick source for fresh drinking water where it is needed most."

"The work comes out of necessity, certainly for California, but there are also many places around the world that share our same challenges," Cohen said. "I feel we have an opportunity to make a real impact with our work. We're pointing out where advanced technology can make a difference. We're trying to find real solutions, and in this area, UCLA is certainly leading the way."

Creating the M3 was a unique multidisciplinary team project involving faculty and students from the chemical, electrical and civil engineering departments with expertise in control theory and optimization, process design/monitoring, computational fluid dynamics, thermodynamics, and software development.

Source: University of California - Los Angeles