New tool helps parched regions plan how to replenish aquifers

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Credit: AI-generated image (disclaimer)

The federal government reports that 40 states expect water shortages by 2024 and water worries already plague some cities across the United States. Underground aquifers that were over-tapped for years now cry out to be replenished. The problem is that the two main strategies for increasing water supplies – collecting stormwater runoff and recycling treated wastewater – are usually separate processes that can create costly and underused infrastructure.

Now two Stanford environmental engineers have developed a computational planning tool called AquaCharge that helps urban water utilities look at their local circumstances and understand how they could combine these two water supply strategies into an integrated, efficient and cost-effective system that replenishes aquifers.

This planning tool and hybrid approach are so innovative that the American Society of Civil Engineers recently honored Jonathan Bradshaw, a graduate student in civil and environmental engineering, and Richard Luthy, a professor of civil and environmental engineering, for developing AquaCharge.

"The ideas of recycling waste water and capturing stormwater are not new," said Luthy. "What's new here is to think about how to combine what had been separate systems into a single approach to recharge groundwater."

Cost vs. need

Neither strategy for increasing water supplies is without drawbacks. A number of utilities in California collect stormwater, such as the rainfall that pours down mountainsides during the wet season, and channel it into big "spreading basins," which are essentially leaky ponds that are porous enough for water to percolate back down to an aquifer. Aquifers serve as natural storage banks, holding water for future use instead of letting it wash out to the ocean.

Although this approach is effective, spreading basins require a large amount of land that is often underutilized. That's because engineers typically designed the basins to be big enough to capture and process large volumes of water during the stormy season. As a consequence of this design, the basins remain largely idle through the dry months. By some estimates, Los Angeles' spreading basins on average percolate only 12 percent of their theoretical annual capacity. Not all districts have access to land that can lay idle so much of the year.

Wastewater recycling poses a different set of challenges. Some utilities treat wastewater to the point that it can be used safely for agricultural irrigation or certain industrial purposes, such as circulating through the cooling towers of a power plant. Such uses reduce the burden on aquifers or other water sources.

However, regulations require that this recycled water be conveyed in a pipeline separate from drinking water pipes. Although many cities have a large potential to produce recycled water, the high cost of such separate piping systems means that only a small fraction of this potential actually gets developed. And so most treated wastewater flows back into the sea, or into rivers and streams.

A hybrid system

With these trade-offs, regions may decide that the land requirements or piping costs drive them toward one or the other system. However, other communities have developed hybrid approaches combining the two strategies.

Orange County, California, which has become a leader in groundwater replenishment, purifies its wastewater so that it is clean enough to drink – then pumps this highly purified recycled water into spreading basins to recharge the region's underground aquifer. This is analogous to stormwater capture in the sense that the water percolates back into underground storage banks, except that the water source is purified wastewater rather than rainfall or snowmelt.

Inspired by water reuse leaders like Orange County, the Stanford researchers created AquaCharge to assist other local authorities in comparing the tradeoffs between different designs in order to find the most cost-effective system in their region.

The software looks at factors such as the availability of spreading basins and stormwater supplies, the potential to produce recycled water and options for installing recycled water pipelines.

"Our method not only allows you to think about a new kind of hybrid water replenishment system," Bradshaw said. "It also helps determine what sort of system will meet a city's goals at the lowest cost."

Luthy said AquaCharge could greatly improve the use and reuse of water. California, for instance, currently recycles about 15 percent of its available treated wastewater effluent. State water planners would like to double or triple that amount by 2030.

By allowing communities to make complex calculations that reveal costs and benefits of reuse strategies, Luthy says, "AquaCharge could help the state meet that goal."

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