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Treating Sewage For Drinking Water New California plant cleanses water to replenish supply

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PERHAPS YOU'VE SEEN the signs: "This property is irrigated with reclaimed water. Do not drink." Reclaimed or recycled water is wastewater—sewage—that has been purified for reuse, most commonly for irrigation.

But with water woes growing in parts of the U.S.—a nearly two-year drought has parched the Southeast, while drought, environmental concerns, and population growth have put pressure on water supplies in western states—water utilities are scrambling to find new ways to meet the demand for one of life's essentials.

One option is to recycle waste for drinking water. Yes, that means drinking water reclaimed from sewage.



Orange County Water District

Recycling Water An array of reverse-osmosis filters cleans wastewater before it's returned to Orange County's groundwater supply.

Some communities have used reclaimed water for decades to recharge their drinking water supplies. In Virginia, recycled water is added to a stream feeding the [Occoquan Reservoir](#). In Los Angeles, treated wastewater is added to the [Montebello Forebay](#), where it percolates through the soil to replenish the groundwater supply. Also in California, the [Orange County Water District's](#) (OCWD's) [Water Factory 21](#) facility reclaims wastewater that is then injected into aquifers to provide a pressurized barrier against seawater intrusion into groundwater.

To meet additional need to prevent such intrusion and to meet increased demand for drinking water, the [California Department of Public Health](#), along with the [Santa Ana Regional Water Quality Control Board](#), approved OCWD's new state-of-the-art water reclamation facility on Jan. 10. The Advanced Water Purification Facility (AWPF) will yield

70 million gal of drinkable water per day, or about 10% of the district's daily need for 2.3 million residents. "It will give us a supply unaffected by drought," notes Meहुल Patel, OCWD's principal process engineer.

AWPF is the largest water reclamation plant in the U.S. The water goes through multiple purification steps designed to reduce levels of organic chemicals, pathogens, and emergent chemicals of concern such as endocrine disruptors and pharmaceuticals. The product is as clean as and probably cleaner than standard tap water, Patel says.

Starting as sewage from industrial and household discharge, the wastewater is initially treated by the [Orange County Sanitation District](#). Large items such as branches are first removed by a grate with bars about 1 foot apart. Then gritty material such as sand and coffee grounds is allowed to settle to reduce wear on pumps.

Next comes the primary clarification step, in which metal salts such as ferric chloride and anionic polymers are added to encourage suspended matter to clump together and settle out of the solution, in a process called flocculation.

The water then moves to an aeration or activated sludge process in which bacteria and other microorganisms are added to the water to break down organic material, including fecal matter. Secondary settling removes the organisms and any additional particulate matter.

At this stage, the water is called secondary effluent and would normally be discharged to the ocean. Additional treatment would be needed to make the water usable even for nonpotable applications such as irrigation, never mind for drinking water. It is at this point the water enters OCWD's AWPF.

The first step at AWPF is to add sodium hypochlorite to disinfect the water. The hypochlorite reacts with ammonia in the water to produce chloramine, which then stays in the water throughout the plant as a disinfectant and antifouling agent. The stream is sent through microfiltration filters to remove any remaining suspended solids and microorganisms such as bacteria, although some viruses will get through. OCWD uses Memcor polypropylene microfiltration membranes from Siemens.

The pore size of the membranes is about 0.2 μm . A major challenge in making the membranes is to balance selectivity for removing contaminants with permeability to maintain an adequate flow rate, says Paul Gallagher, director of research and development for [Memcor](#) products. Chemical resistance of the membranes and their support structures is also critical.

The biggest issue with the membranes is fouling. Organic material such as cell fragments, dissolved proteins, or extracellular polysaccharides can form an organic layer on the membrane surface as well as adsorb onto pore walls. Inorganic fouling typically involves precipitation of metal hydroxides onto membrane surfaces. Every three weeks, the membranes must be cleaned with sodium hydroxide to remove organic residue and then with citric acid to target inorganic material. Biofouling—the accumulation of microorganisms—is also a problem. Research at OCWD involves using infrared spectroscopy and atomic force microscopy to try to identify and classify fouling layers so more effective chemical cleaners can be developed.

After microfiltration comes reverse osmosis to remove dissolved contaminants. The main goal is to remove minerals or salts in the water, but ammonia and viruses are also targets. OCWD's reverse-osmosis membranes are made of a polyamide material and manufactured by [Hydranautics](#), a subsidiary of Nitto Denko. Unlike the microfilters, which have distinct pores, the reverse-osmosis membranes are more like a fabric. The permeability of the fabric determines what will be retained and what will be transmitted through the membrane. The shape and charge of molecules play a role, but size is still the overriding factor. Anything above a molecular weight of 150 is likely to be removed. Sneaking through might be low-molecular-weight organics from pharmaceuticals, personal care products, and industrial solvents.

As with microfiltration membranes, makers of reverse-osmosis membranes must strike a balance between selectivity and permeability. They must try to get as much out of the water as possible while maintaining low pressure and adequate flow. Manufacturing is key in that more consistent cross-links—that is, fewer breaks in the mesh—will improve both salt rejection and water flow, says Rich Franks, applications manager at Hydranautics.

Because reverse-osmosis membranes receive water already purified through microfiltration, they need to be cleaned only about every six months. Sodium hydroxide serves here, too, along with a surfactant to remove

biolayers of microorganisms. One drawback of reverse-osmosis membranes is that they're degraded by chlorine, although chloramines are more forgiving. Research projects at Hydranautics include altering the character of the membrane surfaces so they're less tolerant to fouling and engineering membrane-module construction so the module is less likely to trap foulants.

The final treatment step at AWPf removes low-molecular-weight organics by adding hydrogen peroxide and irradiating with ultraviolet light. Hydroxyl radicals or hydroxide anions will oxidize at least some of the remaining organic contaminants.

WHEN WATER exits the plant, it goes to one of two places. About half is pumped to the coast, where it is injected through wells to form a hydraulic barrier to prevent seawater intrusion into groundwater. The other half is destined for a percolation pond, which is essentially a giant lake set in permeable soil that allows water to percolate down to blend with the groundwater table. Additional filtering occurs in the soil, where naturally occurring bacteria may break down any remaining contaminants. Studies done for the original Factory 21 reclamation plant using noble gases as tracers demonstrated that it takes more than six months for water to travel from injection wells or percolation ponds to drinking water well intakes.

AWPF was more than a decade in the making, incorporating design, process validation, construction, and regulator approval. The facility's end product is water that meets or exceeds all drinking water standards. "There are hundred of constituents that we have to test for and then report," OCWD's Patel says, "and there are minimum standards for all of them."

At a national level, the [Environmental Protection Agency](#) is seeing greater interest in and discussion of using treated wastewater to recharge aquifers, says David Albright, manager of the groundwater office of [EPA's Pacific Southwest Region](#). He is unaware, however, of any other plants in the works. As water supplies tighten, perhaps more communities will be asked to put their faith in chemistry and accept recycled water into their drinking supply.

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