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New desalination technique yields more drinkable water

A new, more energy-efficient seawater distillation membrane yields more potable water, and less briny discharge.

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More than a third of the world already suffers from shortages of potable water—with a rise to 50 percent expected by 2025. Desalination of seawater can help coastal communities can address local shortfalls, although the process is costly, and releasing leftover brine back to the ocean has environmental implications. Now a new system promises to produce more drinkable water with less salty effluent.

Kamalesh Sirkar, a New Jersey Institute of Technology (N.J.I.T.) distinguished professor of chemical engineering, says he has devised a direct-contact membrane distillation (DCMD) system that can efficiently wring drinking water out of up to 20 percent-salt-concentrated brine. (After about 25 percent, salt precipitates out of the solution in the membrane distillation system and could damage the membranes, pumps, lines and other components, Sirkar says.)

Normal seawater has a salt concentration of about 3.5 percent, which means the new system can reprocess the same seawater several times. "More water can be recovered with less residue," Sirkar says.

MEDIO IMAGES

Seawater can be turned into drinking water, but the process is expensive.

In Sirkar's system, heated seawater flows across a membrane strung with a series of hollow tubes made of a porous, yet hydrophobic, fiber—meaning only water vapor can be osmotically transferred. Cold distillate water runs through each of the tubes in a direction perpendicular to that of the seawater. The temperature difference between the heated seawater and cold distillate water causes vapor to form on the tubes. This vapor diffuses through the pores and condenses again inside the tubes, joining the flow of cold distillate water. The salt cannot penetrate the tubes and is carried away; with each cycle, more fresh water is drawn off, leaving more highly concentrated brine behind.

Sirkar's recently patented system can deliver about 80 liters of drinking water per 100 liters of seawater, he says. A comparable reverse-osmosis system—which relies on pressure to force seawater through a salt-filtering membrane—would reclaim 41 liters from that same amount of saltwater, according to Sirkar.

Membrane distillation's advantages include its ability to produce drinking water with very low salinity. In addition, seawater can be distilled at a range of temperatures—from 30 to 100 degrees Celsius—reducing the amount of heat typically needed for desalination, an energy savings, Sirkar says. Prolonged use may decrease a typical membrane's efficiency, but Sirkar says his system adds an ultrathin layer of a highly porous silicone–fluoropolymer coating to extend membrane lifetime. Fluoropolymer—a polymer that contains fluorine atoms—has a high resistance to the solvents, acids and bases found in ocean water. As for the environmental impact of desalination, Sirkar says dumping concentrated brine back into the sea creates a "minimal" disturbance to sea life. He adds, "Seawater is a very large volume with enough turbulence to dilute [the brine] very quickly."

That's not to say membrane distillation is without problems. It requires a steady, inexpensive source of heat to prevent the temperatures of the water on either side of the membrane from equalizing, which would impede the vaporization/condensation process. For DCMD to be practical it needs to be easier to use, more cost-effective and able to take advantage of available heat sources, including waste heat produced by places such as shore-based factories and offshore drilling operations, Sirkar says.

Although membranes are getting better, reverse osmosis is more common and has been used in desalination plants since the late 1960s. Recent improvements in reverse-osmosis technology—including more efficient membranes made from carbon nanotubes and energy-recovery devices that

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boost output while cutting energy consumption and costs—have made it a feasible option for even small communities such as the Sand City, Calif., on the Monterey Peninsula, with a population of less than 350.

Whichever technology is used for desalination, the price tag remains a wild card, dependent on the cost of energy necessary to build and maintain the facility, run the process, and transport seawater in and desalinated water out. A recent study by the WateReuse Association indicates that costs for seawater desalination projects vary widely from about $2 to $12 per 3,785 liters. Smaller capacity units, which produce less than 3.8 million liters daily, are at the higher end of that cost range, in part because they cannot leverage the same economies of scale as larger facilities.

As a result, desalination does not figure prominently in the U.S. Environmental Protection Agency's National Water Program 2012 Strategy: Response to Climate Change report, released in March as a draft for public comment. (pdf) The report notes that "desalination is energy intensive and there may be risks and costs associated with disposing of waste brines from the treatment." Still, the agency does acknowledge that rising sea levels over time may increase saltwater intrusion on coastal freshwater aquifers and notes that desalination is one way to ensure those aquifers remain usable.

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