From seawater to freshwater with a nanotechnology filter

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In this month's *Physics World*, Jason Reese, Weir Professor of Thermodynamics and Fluid Mechanics at the University of Strathclyde, describes the role that carbon nanotubes (CNTs) could play in the desalination of water, providing a possible solution to the problem of the world's ever-growing population demanding more and more fresh drinking water.

Global population projections suggest that worldwide demand for water will increase by a third before 2030.

But with more than a billion people already experiencing drinking-water shortages, and with a potential 3-4 ^{o}C increase in temperature and subsequent redistribution of rainfall patterns, things are likely to get even worse.

CNTs – essentially sheets of one-atom thick carbon rolled into cylinders – have been investigated by Reese and his research group, using computer simulations, as a new way of addressing this challenge and transforming abundant seawater into pure, clean drinking water.

Their technique is based on the process of osmosis – the natural movement of water from a region with low solute concentration across a permeable membrane to a region with high concentration. But just as with most existing water-desalination plants, Reese's technique actually uses the opposite process of "reverse osmosis" whereby water moves in the opposite direction, leaving the salty water clean.

One can imagine a large tank of water, separated into two sections by a permeable membrane, with one half containing fresh water and the other half containing seawater. The natural movement of water would move from the fresh water side to the seawater side to try and dilute the seawater and neutralize the concentrations.

But in reverse osmosis a large amount of pressure is applied to the seawater side of the tank, which reverses the process, making water move into the fresh-water side and leave the salt behind.

Although this process can remove the necessary salt and mineral content from the water, it is incredibly inefficient and producing the high pressures is expensive.

Reese has, however, shown that CNTs can realistically expect to have water permeability 20 times that of modern commercial reverse-osmosis membranes, greatly reducing the cost and energy required for desalination. Additionally, CNTs are highly efficient at repelling salt ions, more so because specific chemical groups can be attached to them to create a specific "gatekeeper" function.

As Reese writes, "The holy grail of reverse-osmosis desalination is combining high water-transport rates with efficient salt-ion rejection. While many questions still remain, the exciting potential of membranes of nanotubes to transform desalination and water-purification processes is clear, and is a very real and socially progressive use of nanotechnology."

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