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SQUEEZING WATER FROM THE SEA

Improvements in a technique called reverse osmosis are gradually making desalination a practical technology. Even so, plugging holes in leaky mains might still be a better way to increase the water supply

"Water, water everywhere, nor any drop to drink," rimed the Ancient Mariner. He was broadly right. Three quarters of the earth's surface is aqueous, but only $2^1/_2$% of the water is fresh and around two thirds of this relatively small amount is frozen in Antarctica and Greenland, of little use to man or beast.

Most of the time, the remaining fraction—the unfrozen, fresh water that fills the earth's lakes and rivers—is enough to supply human needs. But cost, and concern to preserve attractive valleys from the fate of becoming reservoirs, is encouraging water companies to look anew at extracting freshwater from the sea. Better technology is bringing the price of doing this to a point where, in some cases at least, the idea is worth considering.

There are two ways of desalinating water. The traditional one—employed mainly in the oil states of the Persian Gulf, where energy and money are abundant and natural freshwater is rare—is distillation. This imitates the natural water cycle, in which water evaporates from the ocean and condenses into clouds, returning to earth as rain or snow. In distillation-based desalination plants, salty water is heated to produce vapour, which is then condensed to produce fresh, potable water.

Nature does the job of evaporation with heat from the sun. An artificial plant requires artificial heat. This makes the water it produces expensive. In Spain's Canary Islands, for example, distilled water costs about $1 a cubic metre—three to four times as much as conventional local water sources. There is, however, a second way to desalinate water—a way that is more flexible than distillation, and often cheaper. This method is known as reverse osmosis.

Osmosis is the process by which living cells take up water. Cells are surrounded by membranes that are "semi-permeable"—that is, they let water through, but not (unless special molecular pumps are activated) the sodium and chloride ions that constitute salt. If the concentration of salt inside a cell is, nevertheless, higher than that outside it, water will flow in across the membrane to try to equalise the dilutions on both sides. This osmotic flow can be reversed by applying pressure to the fluid on the inside of the membrane. The water goes out; the sodium and chloride ions don't.

In principle, reverse osmosis could be carried out on a more human scale simply by putting a semi-permeable membrane over the end of a pipe and sticking it so deep in the ocean that the pressure of the water above it forced fresh water through. In practice, the rate of production would be too small to slake the thirst of a city, and it would be difficult to keep the membrane clean. For better results, seawater is first passed through an ordinary filter to remove suspended solids and then has chemicals added to it to prevent the growth of micro-organisms on the membrane's surface. Then the water is forced through a membrane at a pressure of around 67 atmospheres, leaving the salt it once contained behind.

Reliable reverse osmosis is transforming desalination. Engineers began work on the process in a serious way in the 1970s, but its early years were full of problems. The first membranes were made of cellulose acetate. These did the job, sort of, but not for very long or very well. Cellulose membranes tended to last only a few months—bacteria found them tasty and would eat them—and even when working at their best they caught only about 85% of the salt.

Now, thin-film composite membranes do the job. The backing material is made of a porous plastic film. Such composite membranes last years rather than months, and even the most omnivorous bacteria find them inedible. Also, they can process up to ten times more water per square metre than cellulose membranes could, and use perhaps half as much pressure to do so, reducing energy costs considerably. In fact, every bit of the reverse-osmotic process is cheaper and better than before.

Desalination is still dear compared with digging a nice deep well, but less so compared with having to build something big, like a reservoir, from scratch. In Florida, for example, dozens of reverse-osmotic plants are used to treat brackish water that would otherwise be undrinkable. The treated water is mixed with the regular water supply. The result is to "extend" the local water supply.

Economies of scale have helped bring new business. A plant capable of processing 75,000 litres a day (l/d) was considered large in the 1980s. Now, plants turning out more than 45m l/d are routine.

But distillation is hardly doomed. Reverse osmosis is still unsuitable for much of the Middle East: Gulf water has more salt in it than ocean water, and it is also "loaded with silts and wild biological activity", according to James Birkett, a consultant for the International Desalination Association. Moreover, the warm Gulf water reduces the useful life of the membranes.

Engineers at California's Metropolitan Water District (MWD), working in collaboration with a California engineering firm and an Israeli desalination outfit, think they have an economic breakthrough in the works. The trio have spent the better part of $10m and three years designing a new, improved distillation plant. They have worked out how to use cheaper materials to keep construction costs down. And they have reached for the skies—literally. Their plant would be more than 120 metres high. The typical desalination plant is a low, messy sprawl.

The designers say taller is better as it uses less land and is therefore cheaper. The business-development manager at the MWD estimates that the new design should turn out water for less than 50 cents a cubic metre. All the consortium needs to prove the point, she acknowledges ruefully, is a customer. For even in countries that might be thought natural markets, the powers-that-be are sceptical of such ideas.

How is a bureaucrat to know when desalination makes sense? The answer is not always obvious. Despite Israel's aridity, official policy is to avoid large-scale desalination for as long as possible. Mekorot, the national water agency, argues that the country would do better by reclaiming waste water, catching more flood water and improving the management of municipal supplies. It is surely right. The best way to improve water systems is often simply to fix leaks, and not to give the stuff away, as many Gulf states do. In rich countries like Britain, more than a quarter of all water is lost in transmission. In poor countries, the figure is commonly more than half. Mending leaks and charging are technologically unglamorous—but they work. Desalination has its uses, but should remain a last resort.