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Reverse Osmosis and Toray Membrane USA: Can Desalination Finally Solve Water Scarcity?

Randy Truby

Questions remain regarding the impacts of climate change on water supplies, but technology advances in water reuse and desalination clearly offer compelling solutions for global water challenges. In the following **VerdeXchange News** interview, **Randy Truby**, CEO of Toray Membrane USA and a panelist at the GreenXchange Leadership Conference in December, describes reverse osmosis membrane technology, which is on the verge of moving from prototype to implementation in the water supplies around the country.

For those unfamiliar with "reverse osmosis," please describe the process, it's uses, and it's origins.

When reverse osmosis was first talked about it, the ultimate goal was to take seawater and apply pressure, leaving the salt behind and forcing freshwater through a semipermeable membrane. It was the reverse of the natural process of osmosis—where a semi-permeable membrane divides a pure water stream from a salt water stream, and the flow of water moves from the pure side to the salty side. In the 1800's it was theorized that if you put a higher pressure on that salty side than the osmotic pressure, you can drive water in the other direction, out of the salty solution. The first membranes invented in the '50s and '60s were cellulose acetate. They worked well, but they required too much pressure, which made the process uneconomic. And the membrane was biodegradable, so there were concerns with bacteria attack and that sort of thing. In the late '70s and early '80s, a polyamide membrane was invented in the United States under sponsorship by the U.S. Government. This polyamide membrane had the properties that everybody was looking for: it allowed a lot of water to pass through the membrane with much less pressure and with very high salt retention characteristics, so energy consumption came way down. At the same time, because it was a synthetic polymer, it wasn't subject to biological attack.

From that moment on, reverse osmosis has become a widely used technology for removing impurities from water. It then turned out that reverse osmosis could be used for more than seawaterdesalting. It's also used to take city tap water and make ultra-pure water for industrial use, like the semiconductor industry. All the power stations in the world, essentially, have reverse osmosis systems to purify water before they put it into their boilers to make power. It further turned out that reverse osmosis also had capability for food-processing applications, and so reverse osmosis is used to separate protein from cheese whey and to concentrate sugars. Later, it was demonstrated that it had the capability of reclaiming wastewater. There are now huge reverse osmosis systems in the world treating municipal sewage with some pre-treatment processing to keep the membranes clean. The sewage can be recovered, the water squeezed out of the sewage and either used for indirect use like irrigation of landscaping, or it can be used for industrial sources of water; for example, in Los Angeles, the refineries there reclaim sewage and use it for ultra-pure water for their boilers. It also can be used for direct recycle, and some places in the world, like Singapore, have a very aggressive program to recover sewage and use it in their drinking water system, with a whole series of safeguards that they put in place.

What has been Toray's place in these markets over the years, especially in the United States?

Toray is a large Japanese company. It was founded in 1926 as Tokyo Rayon. They have always been in the textile and chemical business. The tagline for the company is "Innovation by Chemistry." They've invented a whole series of high technology chemical polymer products. Because Toray was very strong in polymer chemistry, they got involved in this polyamide membrane part of the reverse osmosis business in the late 1960s and early 1970s. They had been a supplier of reverse osmosis membranes since the mid-1970s. Today, they are the number-three supplier around the world of polyamide membrane. They have been expanding. In looking at the global markets, the U.S. market is one of the biggest markets for membranes. Toray has a major, primary manufacturing site in Japan, but they decided they wanted to build a factory in the United States, so they did a survey and decided Southern California was the place they wanted to put the plant. In fact, we are in Poway, California, just outside of San Diego.

What buyers and markets does Toray Membranes now market its reverse osmosis products to?

Reverse osmosis has been used widely in the United States, as I said, by semiconductor manufacturers all over the Silicon Valley, Texas, and places like that. It has been used in power stations: PG&E, So. Cal. Edison, and San Diego Gas & Electric. They all use reverse osmosis widely, as do most of the power companies in the United States. Municipalities also use it widely. The Orange County Water District has a huge reverse osmosis system recovering wastewater, as do the West Basin Municipal Water District and the city of Scottsdale, Arizona. So, there are large municipal installations, both for recovering wastewater, mostly for landscape irrigation, but also in parts of the country where there is brackish well water or surface water, they use reverse osmosis brackish-water membranes to remove the salt and make a better quality drinking water. All over Florida, there are large reverse osmosis systems converting brackish well water into drinking water. It has been a very big market, but the future market is likely to be seawater desalting. Right now, there are large plants being planned for Carlsbad, California and Huntington Beach, California. It's being evaluated for Cambria, Santa Cruz, and Marin County. Places in Texas—Brownsville and Corpus Christi—are looking at large seawater desalination facilities, and these will all use the reverse osmosis process because recent technology has made reverse osmosis much more economic for desalting seawater.

What has been the reaction of the public sector to desalination?

Government has been very receptive. A non-profit organization called the Affordable Desalination Collaboration formed in the state of California as a public/private venture that has funding from some of the municipalities like Orange County, West Basin, and the city of Santa Cruz. It also has funding from the state of California's Department of Water Resources, the U.S. Bureau of Reclamation, and then some of the industrial companies. They've built a full-size, state of the art seawater desalting plant, and are operating it at Port Hueneme, just outside of Oxnard, California in order to demonstrate the actual cost of desalting seawater. Their goal was to show that the energy efficiency of modern seawater reverse osmosis systems had improved to the point where it actually consumes less energy than it takes to pump water in the State Water Project from Northern California to Southern California, and that it's very similar to what it costs to pump water from the Colorado River to Southern California. In fact, they finished their first run about a year ago and published their paper. Sure enough, the energy consumption for seawater R.O. was less than what it cost to pump water in the state water project, and just about the same as it is for the Colorado River Aqueduct.

So, desalting has improved so much using membranes and energy recovery devices that the energy cost is much lower than it used to be. It has made the process much more economical. For example, when the Santa Barbara seawater R.O. system was built in the early 90s, it cost about four times what it currently costs to desalt seawater—seawater desalting costs only 25 percent of what it did just 15 years ago. So, we found out very quickly that the technology has improved and is more energy efficient—exactly what the Affordable Desalination Collaboration demonstrated.

How did Toray participate in California's desal demonstration project?.

Toray is one of the sponsors. We have provided funding and free membranes; we've also provided personnel. I currently serve as the chairman of the board for that organization, so I'm actively involved in it on a day-to-day basis in conducting the tests. We test all competitors' membranes. We've tested three different membranes now, because we want to show that it isn't just one technology that would do it, but that there are interchangeable technologies that state water agencies, municipalities, and stakeholders can take advantage of to provide a source of drinking water for their clients.

Toray has been called the Dupont of Japan. Is that a fair comparison?

I haven't heard that before, but it probably is a fair comparison. I think Dupont is much larger; Toray's annual revenues are running about $13 billion, and that's not quite as big as Dupont. However, Toray has joint ventures with Dupont and has done some work with Dupont in the past, and clearly, both of them are in the same kinds of industries. They both have a very high quality reputation for excellence in research and product development; certainly Toray fits into that category.

With climate change concerns increasingly dominating public agendas and energy cost driving innovation, isn't it difficult for procurers in the marketplace to decode and make sense of the evolving green products and services? How do your clients navigate—other than joining you at the upcoming Greenxchange Global Marketplace Conference in December—and stay abreast of all alternatives?

That's exactly why we created, and a number of municipalities have joined, the Affordable Desalination Collaboration, because the municipalities recognize that they need to keep their client base in tune with the improvements in the technology and that they need to perform their due diligence to show that they're hands on in how this technology works. We publish that information widely. We do try to do some public outreach, and in fact, we have a "second go-round" called the Affordable Desalination Collaboration II that received Prop 50 funding from the state of California. We also have a second round of testing underway, and we plan on doing some very extensive public outreach and much larger, more extensive testing to demonstrate the energy efficiency of seawater desalination using membranes. When I hear people quote numbers on what it costs to desalt seawater, they're usually quoting numbers that are ten years old and they don't have current information. That's because it tends to be high-tech, and technology people tend to talk to each other at technical conferences. But your questions is spot on—we do have to do more public outreach to keep the public informed, and we're starting to do that now.

If we have an opportunity to interview you a year from now, what will we likely be talking about?

We'll be talking about osmotic power. When we started this interview, I defined reverse osmosis, which is where you have this osmotic pressure and you overcome it by applying pressure on the salty side. Well, that osmotic pressure represents a potential source of energy. That was postulated in the 1970s by the originators of the reverse osmosis concept but at that time the technology didn't exist to capture that osmotic pressure and turn it into power. Today, because of technological improvements, it is conceivable that we will be able to capture the osmotic pressure from seawater and make it a source of power. We are working on that now. There's a program that has been started by Statkraft, which is a large Norwegian power provider, that is working very hard to build a large demonstration plant that will create energy by harnessing the osmotic pressure through the use of membranes. Toray and my team are working with Statkraft as part of a larger group; there is a whole bunch of people and companies involved. Our group's specific part of the effort is to try to create a new membrane module device that will do this efficiently so that the power harnessed from osmotic power is efficient and cost-effective. Osmotic power will be completely new, and it has nothing to do with pure water. It has to do with making energy using the osmotic process.

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