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New reverse osmosis system boasts almost zero percent discharge waste

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ANAHEIM, Calif. — Only 0.3 percent of the earth's fresh water stores are usable for human consumption and industrial needs. Due to rapidly expanding populations and industrial growth, water shortages are expected to arise in the near future. While this may seem to be a bleak picture, a solution does exist.

The naturally occurring process known as reverse osmosis (RO) can purify water for both industry and human consumption. RO works by applying pressure energy across a polymeric film, or semi-permeable membrane, where pure water is produced from high salinity and/or chemically or biologically contaminated water.

The RO process is cost-effective, which will enable its implementation in areas that lack adequate monetary resources. Eventually, RO membranes will become a fundamental tool in the treatment process for industry, municipal treatment plants, and residential dwellings.

Unfortunately, membranes, especially RO, are prone to fouling and require costly water pretreatment. Additionally, scale formation due to hardness and silica, limits RO productivity (also known as permeate recovery) to about 70 percent.

However, Advanced Water Solutions (AWS) and O'Brien & Gere have found a way to reduce the liquid waste RO produces to nearly zero percent. The ARROW™ water treatment system uses low-cost RO membranes, treats 95 to 99 percent of raw contaminated water and produces almost zero waste in an economical manner.

RO reduction. A new reverse osmosis water treatment system has been developed by O'Brien & Gere that the company says reduces the volume of discharge waste down to nearly zero percent. The units shown here are similar to those installed at an automotive facility in Saltillo, Mexico.

An automotive facility in Saltillo, Mexico needed a water purification system to reduce contaminants of the water provided from a local aquifer. The water from the aquifer was hard (3000 mg/L as $CaCO_3$) and contained sulfate (1200 mg/L), silica (40 mg/L) and a high overall TDS (>2700 mg/L).

The ARROW™ system was installed on-site and produced high quality water at a recovery exceeding 95 percent. The biggest surprise was that the plant showed no sign of membrane fouling or scaling for more than two months.

Effective pre-treatment was applied to mitigate surface fouling of the spirally wound RO membranes due to the rapid deposition of colloidal matter, (clays, iron oxides, silica, etc) bacteria and biological by-products. In order to address fouling problems, water pre-treatment is necessary in almost all water recycling applications.

"In the Saltillo plant we were able to utilize low-cost filtration and fouling mitigation tools to keep the build-up to a minimum," said Riad Al-Samadi, President of AWS. "By using fouling mitigation principles that incorporate aeration and charge neutralization, we found we could mitigate both biological and colloidal fouling and maintain a high and steady RO membrane flux."

Soluble and sparingly soluble inorganic compounds will concen-

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trate due to the permeation of pure water through the RO membrane. Eventually, these compounds will become insoluble, and deposit crystalline scale (i.e. calcium carbonate, silica, barium sulfate, and calcium fluoride) which will hinder the permeation of pure water.

This blockage would normally limit the RO system recovery to 70-75 percent. To solve scale compound problems at the Saltillo plant, the ARROW™ process continuously removed the hardness ions from the RO concentrate stream. The water could then be recycled for further purification via the RO membranes.

The success of the first ARROW™ plant led to another trial run of the RO technology at a Tissue Plant in Mexico. Using high pressure RO and a hollow-fiber microfiltration (MF) membrane as a polishing filter for the softened high TDS, ARROW™ recycled the second stage RO reject stream at a 97 percent permeate recovery. It is noteworthy that the raw water feeding this plant had a total hardness of 800 mg/L, a sulfate concentration of 1000 mg/L and a soluble silica concentration of 25 mg/L.

As the world becomes more cognizant of potential clean water shortages, RO will play an important role in providing the cost-effective technology to purify water for human populations as well as industry.

The table below compares a scenario where 1000 gpm of water or wastewater is evaporated to obtain high quality water for industry or municipal use (MVC = Mechanical Vapor Compression).

Overall, an ARROW™ plant operating at up to 99 percent product water recovery will save 70 percent in annual operating costs compared to MVC Evaporators, and up to 30 percent when compared with conventional reverse osmosis with limited recovery, followed by MVC evaporators.

When applied to 1000 gpm, the ARROW process will produce a reject stream as low as 10 gpm, which can be sent to a small solar pond or solar still (depending on location). It may also be evaporated in an economical manner, resulting in close to zero impact on the environment. As much as 990 gallons of much needed pure water will be generated from every 1000 gallons of raw water fed to the ARROW™ unit, regardless of the raw water quality.

For more information, please contact Hu Fleming, Ph.D. – Vice President, O'Brien & Gere, (215) 628-9107, FleminHL@obg.com, www.obg.com.

Estimated annual cost to process 1000 gpm and produce zero liquid waste

RO Recovery (%)	Evaporator (MVC)	RO Plus MVC Evaporator	ARROW™ Plus MVC Evaporator	
			95%	99%
60%	$3,500,000	$1,950,000	$1,200,000	$1,100,000
70%	$3,500,00	$1,700,00.	$1,200,000	$1,100,000
75%	$3,500,00	$1,600,000	$1,200,000	$1,100,000
80%	$3,500,00	$1,450,000	$1,200,000	$1,100,000
Average % Cost Savings	0%	**52%**	**66%**	**69%**
Cost Savings over RO + MVC	0%	0%	**24%**	**31%**

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