Desalination of Brackish Groundwater

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Reports of groundwater quality and availability show that in some areas high concentrations of dissolved solids are the norm (2,3,6,9). For example, in eastern Colorado much of the land is underlain by aquifers containing water with 3,000-10,000 mg/l total dissolved solids (TDS). Aquifers containing water with 1,000-3,000 mg/l TDS are prevalent in much of the rest of the state (9). In several subregions of Wyoming, the dissolved solids concentration in groundwater ranges from 200-9,000 mg/l (9). Other western states including New Mexico, Montana, Arizona, and Utah have areas of poor groundwater quality because of dissolved solids levels (9).

A 1979 U.S. Department of Interior report cited an earlier report by the American Water Works Association (AWWA) stating that more than 3,000,000 persons in the U.S. were served by systems supplying water with more than 1,000 mg/l of dissolved solids (3). Some of the sources contained over 3,000 mg/l TDS. Those persons were served by 1,066 utilities with raw water containing 1000-3000 mg/l TDS and 31 utilities with 3,000-10,000 mg/l TDS in their feed water. Only a few of these were being treated. According to a 1977 article in Desalination (5) which reported a 1973 AWWA study, 10% of the finished water supplies in the U.S. contained more than 500 mg/l TDS, and high TDS groundwater supplies are prevalent in the Northern Great Plains, the Southwest, Illinois, and Florida.

The areal extent of aquifers containing high TDS levels (8), population served by wells producing poor quality water, and present growth in arid areas suggest that increased use of water with high TDS may be required. It is necessary to ask whether this water can be treated to yield water of acceptable quality at a reasonable cost.

Research in treatment technology has produced major advances in the past few years, particularly in membrane technology (6). For example, low operational pressure membranes are being tested, offering savings in energy use, capital cost, and maintenance costs.

The first commercial electrodialysis (ED) plant was installed in 1915. Improvements such as development of synthetic membranes have resulted in large scale application of electrodialysis for reducing dissolved solids in water. The 40 ED plants in the U.S. produce 7 million gallons per day of potable water. (World-wide, 800 ED plants produce 60 MGD of treated water) (2). Source water for ED plants usually has 1000-10,000 mg/l TDS.

Agency

Reverse osmosis has been the subject of significant developmental work since 1953 (2). Most reverse osmosis (RO) plants operate with raw water sources containing 1000-45,000 mg/l TDS. As of January 1977 there were 518 RO plants with a total capacity of 167 MGD (4). Of those, 290 were in the U.S. (3).

Feasibility and cost projections were reported in 1977 for 15 communities served by high TDS groundwater (941-3236 mg/l) (6). The communities studied were located in Colorado, New Mexico, Texas, Arizona, Iowa, North Dakota, Montana, South Dakota, Kansas, and Hawaii and had populations ranging from 720 to 59,000. The treatment cost projections ranged from $0.37/1000 gallons to $1.57/1000 gallons. Technological improvements have led to lower costs than were projected in an earlier study based on 1970-73 technology ($0.42-$2.09/1000 gallons, in 1977 dollars). These technological improvements outweighed increased energy and other costs. The report concludes that in spite of higher costs, the ratio of benefits to costs is probably more favorable now for many communities that lack suitable low TDS water supplies.

The most recent inventory of desalting plants was completed by the Office of Water Research and Technology (U.S. Dept. of Interior) in 1977. Of the 481 desalting plants with capacity of at least 25,000 gallons per day listed in the U.S., 66 were for municipal water supplies (4). Listed plants were located in 15 states.

A three-volume report on commercial membrane desalination plants was published in 1980 by the Office of Water Research and Technology (2). It included detailed information about 24 desalination plants currently operating in the U.S. and in Caribbean nations. Ten of the plants have water sources containing more than 3,000 mg/l TDS. Seven of the ten are groundwater sources, four of which range fom 7,000-10,976 mg/l TDS.

o In Rotonda West, Florida, a 500,000 gallon/day (GPD) reverse osmosis plant has been in operation since 1973. It treats well water containing more than 6000 mg/l TDS at a cost of $1.88/1000 gallons.

o A one million gallon per day (MGD) reverse osmosis plant has been operating since June 1976 in Rock Harbor, Florida. The source water from the Floridan aquifer varies from 5000-9000 mg/l TDS. Treatment cost is $1.35/1000 gallons.

o The reverse osmosis plant in Ocean Reef, Florida treats 930,000 GPD at a cost of $1.26/1000 gallons. The original plant was installed in 1972, with additional capacity installed in 1973 and 1974. The feed water from five wells contains 5000-8000 mg/l TDS.

o A 300,000 GPD reverse osmosis plant was installed in 1974 in Card Sound, Florida. It treats water from five wells containing 5000-8000 mg/l TDS at a cost of $0.89/1000 gallons.

o Lake Killarney in the Bahamas is the source of 9000-18,000 mg/l TDS water that is treated in a reverse osmosis plant. This plant, in operation since March 1977, produces 600,000 GPD of treated water at a cost estimated at $2.75/1000 gallons.

Table 1 shows size, operating cost, and other data for those plants and others treating less highly mineralized water.

Table 1

Summary of commercial membrane desalination plants

Plant location	Size (1000 GPD)	Feedwater Quality TDS mg/l	Source (Surface, Ground)	Cost ($/1000 gal)	Type *	Operating Since	Ref
Lake Killarney, Bahamas	600	9000-18,000	Surface	$2.75	RO	3/77	2
Rock Harbor, FL	1,000	5000-9000	Ground	$1.35	RO	6/76	2
Ocean Reef, FL	930	5000-8000	Ground	$1.26	RO	1972	2
Card Sound, FL	300	5000-8000	Ground	$0.89	RO	1974	2
Rotonda West, FL	500	7000	Ground	$1.88	RO	1973	2
Minitonas, Manitoba	20 (imperial)	3500	Ground	$3.60 (imperial)	RO	1976	1
Dell City, TX	100	3159	Ground	$1.70	EDR	6/76	2
Sorrento Shores, FL	170	3034	Ground	$2.11	RO	10/75	2
Junius Ponds, NY	40	3000	Ground	$4.34	EDR	1974	2
Sorrento Shores, FL	70	2631	Ground	$1.76	EDR	1/74	2
Sanibel Island,FL	1,800	2620	Ground	$1.39	ED	11/73	2
Venice, FL	1,000	2400	Ground	$1.07	RO	10/75	2
Mohawk, AZ	12	2260	Ground	$5.43	EDR	6/70	2
Pine Island, FL	830	2200	Ground	$1.37	RO	3/75	2
Buckeye, AZ	650	2140	Ground	$1.13	ED	9/62	2
Foss Reservoir, AZ	3,000	1960	Surface	$1.33	ED	1974	2
Pattersonville, NY	20	1836	Ground	$4.33	EDR	4/75	2

* RO = Reverse Osmosis ED = Electrodialysis EDR = Electrodialysis with polarity reversal

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