UNIVERSITIES COUNCIL ON WATER RESOURCES
JOURNAL OF CONTEMPORARY WATER RESEARCH & EDUCATION
ISSUE 132, PAGES 1-2, DECEMBER 2005

Desalination: Supplementing Freshwater Supplies Approaches and Challenges

Tamim Younos

Virginia Polytectnic Institute and State University

A broad definition of desalination includes the treatment of all impaired waters; waters contaminated by salts, metals, radionuclides, biologic organisms, organic chemicals, fertilizers, pesticides, and a number of other substances that must be removed prior to water being suitable for potable use. The U.S. Department of Interior, Bureau of Reclamation along with the Sandia National Laboratories has created the Desalination and Water Purification Technology Roadmap to meet future water demand in the United States (Sandia National Laboratories 2003). The U.S. Bureau of Reclamation has published a desalting handbook for planners (U.S. Bureau of Reclamation 2003). Future desalination technologies are expected to treat a variety of impure waters such as urban runoff, wastewater treatment plant discharge, and saline water for possible reuse or underground storage. For the purposes of this report, the definition of desalination is limited to removing salts from brackish water and seawater to produce potable water.

The amount of salt in water is usually described by the concentration of total dissolved solids (TDS) in the water. TDS refers to the sum of all minerals, metals, cations, and anions dissolved in water. Water that contains significant amounts of dissolved salts is called saline water, and is expressed as the amount (by weight) of TDS in water in mg/L. More than seventy elements are dissolved in seawater, but only six elements make up greater than 99 percent (by weight). These major elements occur as electrically charged ions. Table 1 shows the approximate composition of typical seawater by weight and concentration. Seawater is a solution of salts of nearly constant composition.

Table 1. Composition of Seawater

Element	% Weight/ Gram of Water	Concentration (mg/L)
Chloride (Cl)	55.04	19,400
Sulfate (SO_4)	7.68	904
Calcium (Ca)	1.16	411
Sodium (Na)	30.61	10,800
Magnesium (Mg)	3.69	1290
Potassium (K)	1.10	392

Brackish water contains less TDS than seawater, but more than freshwater. Due to a number of factors, the range of TDS concentrations in brackish water and seawater can range between 500 mg/L to 50,000 mg/L, with brackish water TDS concentrations in the lower range and seawater TDS concentrations on the upper end of the range. Most brackish water environments are dynamic and TDS levels in these environments fluctuate spatially and temporally. The salinity of brackish surface water near the coast can vary depending on the tide, the amount of freshwater entering the system (as rain or river flows), and the rate of evaporation. Brackish water can also be found in coastal aquifers and some deep groundwater aquifers contain brackish water that occurs under natural conditions. In coastal aquifers, excessive groundwater withdrawals may cause the seawater to move into freshwater aquifers (a phenomenon known as saltwater intrusion) and create brackish water in the aquifer.

The U.S. Environmental Protection Agency has set the Secondary Maximum Contaminant Level (SMCL) or aesthetic standard for TDS in potable water as <500 mg/L (Poff 1999). A TDS concentration of less than 200 mg/L in drinking water is desirable. High TDS content in potable water is a problem that can cause scaling in pipes, staining of bathroom fixtures, corrosion of piping and fixtures, reduced soap lathering, and objectionable tastes.

Total dissolved salts in brackish and seawater cannot be removed using conventional water treatment processes that include coagulation, sedimentation, and filtration technologies. Desalination technologies are being developed and used worldwide to remove such salts from brackish water and seawater to produce water that meets standards for drinking water or other intended uses. Currently, there are 12,500 desalination plants in the world with a total water production capacity of approximately 6 billion gallons/day (22.8 x 10^6 m^3/d) (Duranceau 2001). In the United States, major large-scale desalination facilities are being developed or planned in Florida and California (Alspach and, Watson 2004, State of California 2003). Texas is also planning to develop its own large-scale desalination facility in the future (Texas Water Development Board 2002). Small-scale desalination plants for treating brackish groundwater are operating in Virginia, North Carolina, and other states (Younos 2004).

The goal of this publication is to provide an overview of desalination technologies, and to present challenges and opportunities in using desalination to supplement drinking water supplies. Issues critical to implementing desalination technologies include the type of technology, the environmental effects and permits/regulatory issues, energy availability and consumption, and the economic aspects of implementing desalination.

Author Bio and Contact Information

Tamim Younos is a senior research scientist and interim director in the Virginia Water Resources Research Center at Virginia Tech. His educational background is in Civil and Environmental Engineering (doctoral degree, the University of Tokyo) with research and teaching interests in environmental hydrology, water source protection, and water supplies and waste management in rural environments. Recently, he authored a report on the feasibility of implementing desalination to supplement freshwater supplies in eastern Virginia. He can be reached at: Virginia Polytechnic Institute and State University, 10 Sandy Hall, Blacksburg, VA 24061-0444. (540) 231-8039; Fax: 231-6673; tyounos@vt.edu.

References

Alspach, B. and I. Watson. 2004. Sea Change. Civil Engineering Magazine, American Society of Civil Engineers. 74(2):70-75.

Duranceau, S. J. 2001. Membrane Processes for Small Systems Compliance with the Safe Drinking Water Act. Presented at the Third NSF International Symposium on Small Drinking Water and Wastewater Systems, April 22-25, 2001, Washington D.C., USA.

Poff, J. A. 1999. *A Guide to National Drinking Water Standards and Private Water Systems*. Virginia Water Resources Research Center, Virginia Tech, Blacksburg, Virginia.

Sandia National Laboratories. 2003. *Desalination and Water Purification Technology Roadmap*. Desalination & Water Purification Research & Development Program Report # 95. http://www.usbr.gov/pmts/water/desalroadmap.html.

State of California. 2003. Water Desalination – Findings and Recommendations. http://www.owue.water.ca.gov/recycle/desal/Docs/Findings-Recommendations.pdf

Texas Water Development Board. 2002. Large-Scale Demonstration Seawater Desalination in Texas. Report of Recommendations.http://www.twdb.state.tx.us/Desalination/FINAL%2012-16-02.pdf

U.S. Bureau of Reclamation. 2003. Desalting Handbook for Planners. Desalination and Water Purification Research and Development Program Report No. 72. (Third Ed.), U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center. 233 pp. (plus Appendix).

Younos, T. 2004. The Feasibility of Using Desalination to Supplement Drinking Water Supplies in Eastern Virginia. VWRRC Special Report SR25-2004. Virginia Water Resources Research Center, Virginia Tech, Blacksburg, Virginia. 114 pp. http://www.vwrrc.vt.edu/publications/recent.htm.