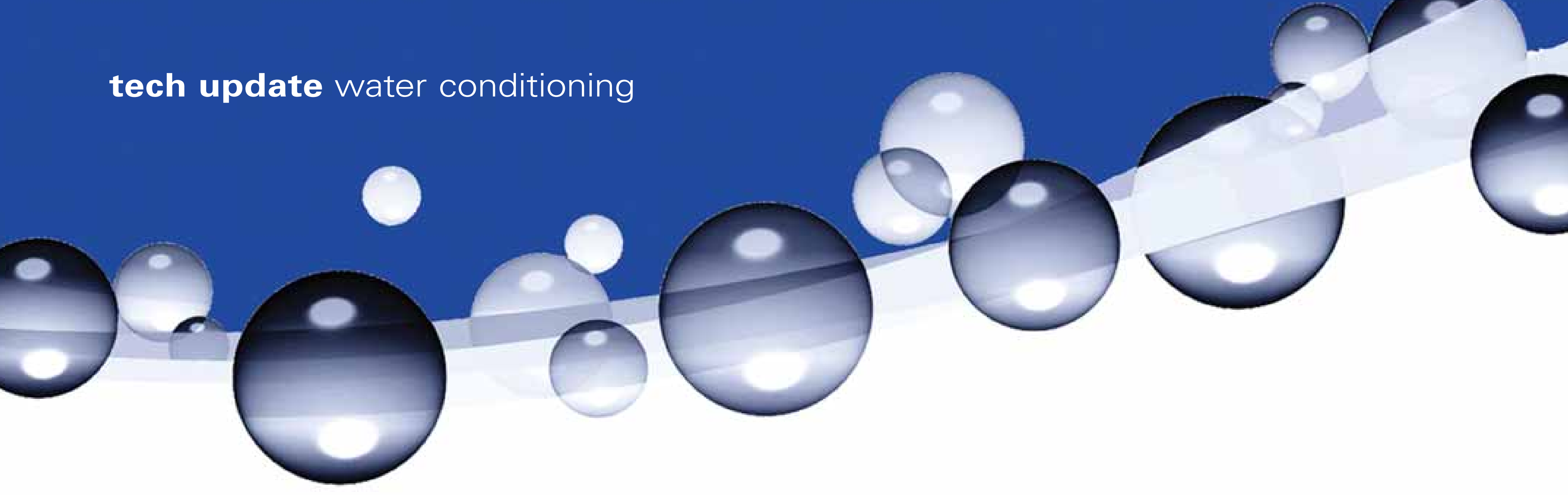

Ion Exchange Developments

By Francis Boodoo

Ion exchange developments spur use in drinking water plants

Advancements in the development of new ion exchange resins, as well as techniques for their application, have allowed for considerable expansion of the use of ion exchange technology in drinking water plants, especially for meeting environmental compliance regulations.

In particular, the traditional role of ion exchange in water softening has now been augmented by use not only for contaminant removal, but for simultaneous removal of multiple contaminants. And where it has been deployed to control total organic carbon (TOC)—for example, to assure compliance with disinfection byproducts (DBP) regulations—it has allowed for previously unusable raw water supplies to contribute to increasing demand.

Contaminant Removal

In McCook, Neb., a 15-year-old nitrate contamination problem that increased in scope over the years to also include uranium and arsenic was solved through the installation of a multi-contaminant-removal ion exchange treatment plant for the city's drinking water. An administrative order from the Nebraska Department of Health and Human Services was lifted just eight months after the treatment plant startup.

To solve the problem, six technology alternatives had been considered originally, including electro-dialysis reversal (EDR), coagulated-aided membrane filtration, enhanced lime softening, iron-based adsorptive media, reverse osmosis (RO) and ion exchange.

EDR was eliminated from consideration because of higher capital costs than RO and ion exchange, higher waste generation than ion exchange and not being generally regarded as well-proven as the other technologies. Meanwhile, there was concern about operating costs for the filtration and softening options. Neither could handle nitrate removal; the adsorptive media could only remove arsenic.

In the end, ion exchange was selected due to its low waste generation (one-fourth of RO for treated water) and its lower overall operating and capital costs. But there were doubts about the ability of an ion exchange media to remove all three contaminants, so a pilot study was set up, taking advantage of new ion exchange application technology.

The proposed media was used in rented equipment to prove the technology's effectiveness, as well as to determine correct sizing for expected loading rates and the amount of salt that would be needed for regeneration. During the design stage, the media provider made extensive use of its new proprietary ion exchange simulation software to model and predict the behavior of the contaminants. This allowed the city's engineering consultants to bypass several months of more extensive piloting that would otherwise have been needed, in a situation where compliance fines were mounting daily.

Because the plant is located in a fairly arid and heavily irrigated area, which has also suffered from drought recently, comparing the water lost to waste during RO and ion exchange had emerged early as a leading concern. RO would have generated about 20% to 25% waste, a substantial loss when the plant peaked out at 5 million gal per day (mgd) during the summer. By comparison, ion exchange was to run at only 1.5% to 2% waste for the total flow.

Thus, the simulation software was critical in gaining confidence for ion exchange as a solution that could handle all three contaminants.

The city's design 6.8-mgd drinking water production system is supplied by nine wells with a combined pumping capacity of 5.5 gal per minute (gpm), derived from individual well input ranging from 177 gpm to 1,400 gpm.

Raw water analyses at the wells show ranges of 0.68 to 28.27 mg/L for nitrates, 9.58 to 18.4 µg/L for arsenic and 15.1 to 54.3 µg/L for uranium. Water exiting the new treatment plant is currently showing nitrate levels at 4 to 5 mg/L, arsenic at 7 to 8 µg/L and uranium at 22 to 24 parts per billion (ppb). Maximum Contaminant Levels (MCLs) are 10 mg/L for nitrate, 10 µg/L for arsenic and 30 ppb for uranium.

A computerized PLC control system operates six cation vessels containing a total of 4,242 cu ft of strong-acid cation exchange resin for softening and 6 anion vessels containing a total of 2,352 cu ft of a strong-base Type II styrenic anion resin, top-dressed with a specially graded strong-base acrylic anion resin.

TOC Reduction

In another application, a special, new ion exchange resin played a key role.

In Frisco, N.C., the plant superintendent for the Dare County/Cape Hatteras Water Treatment Plant reports successful application of an especially long-lasting, strong-base anion exchange resin to allow use of high-TOC (total organic carbon), shallow fresh well water that would otherwise have caused trihalomethane (THM) and haloacetic acid (HAA5) formation in excess of MCLs.

The special resin used is a macroporous Type 1 strong-base resin with an acrylic matrix, which assures very high levels of removal of organic matter from the water supply in conjunction with reversible removal of the organic matter upon regeneration, via nonhazardous sodium chloride.

The resin is regenerated very efficiently, with lower levels of sodium chloride than those required for a polystyrene-based Type 1 resin, but with a comparable ability to remove weak organic acids, lignins and tannins. It is also particularly resistant to organic fouling, even when loadings are relatively high. As a result, it could provide for low-energy, virtually maintenance-free, long-lasting, simple operation, and is thereby credited with making use of the high-TOC well water feasible.

With no surface water available to meet increasing demand for high-quality drinking water from the coastal community, the Dare County Water System developed a combination source of anion-treated shallow freshwater wells and RO-treated deeper brackish water wells as the most cost-effective solution. The anion resin allowed for more use of the shallow well water, despite its high TOC content.

The TOC of the freshwater coming into the anion averages about 12 to 13 mg/L for an average of 50 to 60 color units, and coming out it drops to an average 1 to 1.5 mg/L, which is essentially colorless, and an average 80% to 90% TOC reduction. When that is blended with the output from the RO-treated water in a ratio of about 4:1, the TOC drops down to about 0.85 to 0.81 mg/L.

The TOC reduction keeps THMs in the range of 9 to 30 ppb, and an average of 12 ppb versus the MCL of 80 ppb, and maintains HAA5s at 2 to 5 ppb versus the MCL of 60 ppb. It also maintains average finished water total hardness at 65 to 70 ppm, so the plant does not get corrosion problems from using only RO water.

The 2-mgd combination RO/anion exchange plant is expandable to 3 mgd. Its output is a blend of RO water that derives from four 260- to 308-ft brackish wells at an average RO exit flow of 800 gpm, with anion water that derives from nineteen 70- to 90-ft freshwater wells at an average anion exit flow of 200 gpm. *wqp*

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