

Magnetic Ion Exchange Solves Problems

Colorado's first IX pretreatment system overcame precursor issues in seemingly pristine mountain water. **BY FREDERICK W. PONTIUS, NELSON RENOUF,**

AND ROY MCCUTCHEN

IN 2004, BIG ELK Water Association, near Estes Park, Colo., earned the unenviable Environmental Working Group label of Colorado water system with the worst quality water. Despite multiprocess treatment, BEWA's finished water had some of the highest concentrations of **total trihalomethanes** (TTHMs) and **haloacetic acids** (HAA5) in the state. BEWA delivers water to about 390 people in Big Elk Meadows, a mountain subdivision.

After surface water from a series of aerated lakes is treated by microfiltration (MF), ultraviolet (UV), and sodium hypochlorite for disinfection, as well as granular activated carbon for taste and odor, sodium hydroxide is added for corrosion control. However, quarterly disinfection by-product (DBP) tests showed TTHM and HAA5 levels over 250 µg/L (current limits are 80 and 60 mg/L, respectively). BEWA received a notice of violation from the **Colorado Department of Public Health and Environment** for failing to comply with the maximum contaminant levels (MCLs) set by the **Stage 1 Disinfectants and Disinfection Byproducts Rule**.

How did this happen? Several years of testing had shown that source water levels of dissolved organic carbon (DOC)

were consistently in the 9 to 13 mg/L range. DBPs, particularly TTHMs and HAA5, form when DOC reacts with free chlorine during disinfection. Investigation upstream where raw water enters Big Elk Meadows property revealed high levels of DOC, which the MF/UV plant couldn't effectively remove. The exact cause of the DOC couldn't be determined, and an alternative water source wasn't available.

ALTERNATIVE TREATMENTS CONSIDERED

BEWA conferred with CDPHE, technical assistance providers, and several consultants. Most recommended installing coagulation or GAC adsorption to remove DBP precursors, along with process changes to adjust chlorine contact time (CT) and the use of chloramines. BEWA evaluated several treatment alternatives based on the anticipated environmental impact to the small and delicate Big Elk Meadows ecosystem, chemical use, operating cost, waste generation, and operator licensing requirements. Several technologies were considered, including reverse osmosis (RO), riverbank filtration, advanced oxidation with hydrogen peroxide/UV, chlorine dioxide, dissolved air flotation, and slow sand filtration.

Any process yielding additional waste

requiring direct discharge, such as coagulation/filtration and RO, was unacceptable to BEWA. The association rejected GAC because DOC removal at the levels experienced at Big Elk Meadows would cost too much. Bench testing showed that chloramines effectively lowered TTHM and HAA5 concentrations, but chloramines required too much chemical addition, could potentially aggravate the water quality problems, and DBPs associated with chloramines could possibly be regulated in the future.

BEWA concluded that a long-term solution was needed to solve the high TTHM and HAA5 problem. Precursor removal using a magnetic ion exchange (IX) process was bench tested and found effective. BEWA decided to proceed with design and installation of a 50-gpm IX system.

Extensive bench-scale tests of the IX process were conducted during June and August 2005. Samples of IX-treated water were disinfected using simulated distribution system conditions that mimicked actual BEWA mountain storage and distribution system conditions after disinfection, when historically TTHM and HAA5 levels have been the highest.

The results indicated that IX treatment could reduce raw water DOC levels by



Operator Nelson Renouf observes the magnetic IX process in the resin contactor.

more than 80 percent, to well below the MCLs. The design criteria were based on these results. A 50-gpm magnetic IX system was to be placed in front of the MF/UV plant to remove most of the raw water DOC.

The installation process moved quickly. Because this was to be the first magnetic IX plant in Colorado, the project received conditional CDPHE approval as a demonstration project on Nov. 23, 2005. Construction began in December 2005, and installation was completed for \$160,000 in March 2006.

A nonprofit Colorado corporation operating as a co-op with a membership that includes both full-time and seasonal residents, BEWA is not a taxing district and doesn't qualify as a municipal system, so it couldn't qualify for public assistance. The residents already support high metered water rates: \$0.02/gal up to 3,000/mo; \$0.03/gal for more than 3,000 gal/mo. Each household also pays an annual access fee of \$540. To finance the project, Big Elk Meadows obtained a \$200,000 loan. Based on a five-year payback at 8 percent, an additional \$21/mo surcharge was added to every water bill.

HOW MAGNETIC IX WORKS

The treatment process is continuous IX. The exchange resin enables DOC to be removed in a stirred contactor, much like a flash mixer in a conventional water treatment plant. The resin beads are much smaller than conventional IX beads, approximately 180 μm (80 mesh), allowing rapid DOC exchange in the contactor vessel. The uniformly mixed contactor and small resin beads combine for efficient ion exchange, and low resin concentrations achieve good DOC removal.

Suspended solids don't affect the process, so IX is often the first stage in a treatment plant. DOC removal at the head of the plant benefits downstream processes, such as a lower coagulant dose to achieve targeted water quality and less chemical sludge. Magnetic IX pretreatment also improves membrane flux rates and reduces chemical cleaning of membranes.

DOC removal by IX includes contacting resin with raw water, resin separation and recycle, and resin regeneration. Mixed contacting vessels provide 10- to 20-min detention time during which DOC is exchanged onto the resin. The resin is dosed at 3 percent volume per volume

(v/v), based on settled resin volume. Because magnetic attraction of individual resin beads is limited to short distances, maintaining the resin in suspension requires minimal energy.

The suspended resin water flows by gravity to the resin separation stage. The inlet design is similar to a flocculating feed well for maximum dissipation of inlet jet energy and for interparticle collisions under gentle swirl conditions. This results in "magnetic" agglomeration of individual resin beads that can capably settle against a high upflow. The resulting resin separation exceeds 99.99 percent.

Settled resin is thickened to 20–40 percent v/v and pumped back to the contacting vessel for another loading cycle. From the recycle line, a small amount of used resin is continuously removed for regeneration and replaced with fresh, regenerated resin. Used resin is regenerated with a sodium chloride or potassium chloride solution after a sufficient amount of resin has accumulated.

IMPLEMENTING IX AT BIG ELK

The compact IX equipment was preassembled and delivered on a skid, requiring

