Co-Occurring Contaminants

Arsenic and uranium in drinking water supplies

By James Knoll, Nichole Pennisi & Robert Russor

A significant number of small drinking water systems across the U.S. rely on groundwater supplies. In recent years, however, changes to the drinking water quality regulations established by the U.S. Environmental Protection Agency (EPA) and administered by most states have created challenges for many of these small systems. Two primary drinking water contaminants in particular that have generated considerable regulatory and industry activity are arsenic and uranium.

The EPA standard for safe drinking water for uranium became effective in 2003, establishing a maximum contaminant level (MCL) of 0.03 mg per liter (mg/L). In January 2006, an MCL of 0.01 mg/L of arsenic went into effect, reducing the level from the previously established 0.05 mg/L.

Ongoing water quality compliance testing has confirmed the presence of either arsenic or uranium—and in many cases both contaminants—in water systems across the country. In New England, regulators have identified the co-occurrence of arsenic and uranium, and with the support of the U.S. Geological Survey (USGS), are extending the water quality evaluations to include private residential wells.

Kansas similarly maintains aquifers impacted with naturally occurring arsenic and uranium. In the West and Southwest, where the arsenic problem is most pronounced, co-occurrence with uranium is not uncommon. Sourcing treatment to effectively address both arsenic and uranium removal can represent additional challenges for small community water systems.

Treatment Options

Treatment options for the removal of both arsenic and uranium have been identified by the EPA and include: adsorption; lime softening; ion exchange; reverse osmosis; and coagulation/filtration.

Adsorption technologies have been extensively evaluated and are recognized as the most feasible treatment processes for small water systems. Independent evaluations are concluding that adsorption technologies often present a series of benefits, including:

1. Lower Capital Costs.
   a. Equipment and installation
   b. Packaged units, small footprint
2. Reduced Operational and Maintenance Activities.
   a. Less operational oversight
   b. Less mechanical, electrical sophistication
3. Reduced Waste Generation.
   a. Minimal backwash
   b. No waste sludge generation

When evaluating treatment options for arsenic and uranium, it is often the case that minimal waste generation and waste handling significantly influence the selection criteria.

Experimental Method & Results

To define the treatment effectiveness of an adsorbent technology in source water containing co-occurring contaminants of arsenic and uranium, a small water system in northern Arizona was chosen to conduct on-site, small-scale testing.

The water quality at the site was typical of water quality characteristics found in the southwestern U.S., including concentrations of arsenic and uranium exceeding the MCL, as well as elevated concentrations of vanadium in an elevated pH environment with low calcium and magnesium (total hardness) concentrations.

The treatment design consisted of a single 12-by-54-in. pressure vessel charged with 1 cu ft (40 lb) of adsorbent media. The adsorbent media chosen for the testing program was nanotitanium oxide (MetSorb), based on results realized in previous arsenic and uranium testing experiments.

The well-known effects of pH greater than 8.5 on the adsorption capacity of metal oxide/hydroxide adsorbent media were avoided through pretreatment with a common mineral acid to a pH of 7.3.

Following the pH adjustment, the vessel was fed at a controlled flow rate of 2.5 gal per minute (gpm) providing a total empty bed contact time (EBCT) of three minutes and allowed to operate 24 hours per day, seven days per week.

The raw, untreated and treated water were tested routinely over the course of nearly three months to evaluate the removal efficiency of the adsorbent media for arsenic, uranium and vanadium. The testing was concluded at roughly 500,000 gal of flow through the test unit and the data gathered for evaluation and interpretation.

The data concluded that the nanotitanium oxide adsorbent media effectively removed both arsenic and uranium to below the safe drinking water MCL for each primary contaminant.

The data also suggests a high level of selectivity of the nanotitanium oxide to both arsenic and uranium, given the operation of the test unit at 3.5 minutes of EBCT. An increase in EBCT to four or five minutes would be expected to provide further removal efficiency for arsenic, uranium and vanadium.

The continued application of adsorbent technologies as cost-effective treatment solutions for arsenic removal should be expanded to include co-occurring contaminant challenges such as arsenic and uranium. This becomes even more applicable for small water systems where financial and human resources are limited and cost-effective, easy-to-operate treatment solutions are needed.

It is recommended that a characterization of the saturated media be conducted for proper disposal consideration under the Federal Resource Conservation and Recovery Act as well as state and local disposal restrictions. *wqp*

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