Specialty media developed for arsenic removal

New adsorbents use metal oxides for improved performance.

By Gregory C. Gilles

Since most groundwater in the United States meets the current 50 micrograms per liter (mg/L) standard, there has been limited consumer interest and demand for arsenic treatment for point-of-use (POU) and point-of-entry (POE) systems.

However, this is changing as consumers become aware of the presence of arsenic in their drinking water and manufacturers and dealers seek to be proactive in addressing this emerging need.

Aware of these developments, NSF International's arsenic task force committee representatives are working to reinstate an arsenic reduction claim for drinking water treatment units tested and certified under ANSI/NSF Standard 53.

To date, reverse osmosis (RO) is the only recognized POU technology that is covered under NSF Standard 58 for reducing arsenic. Given the new challenges of potentially removing arsenic to 5 mg/L, improved and cost-effective technologies for the POU/POE industry will be essential to address the estimated 30 percent of the US population served by private wells.

Specialty chemical adsorbents (media) designed for arsenic reduction are emerging as one of the most promising categories of technology to fill this void. Historically, common adsorbents, such as activated alumina, zeolites and even granular activated carbon to a lesser extent, have been used commercially to remove arsenic.

Included in the category of adsorbents also are some emerging specialty types, including metal oxide and iron-based media demonstrated both in the United States and in Europe.

In addition to RO, nonadsorbent-based technologies for arsenic removal include ion exchange, coagulation/microfiltration, iron coprecipitation and lime softening. Each has been shown to be commercially viable for arsenic, particularly As V, removal in larger systems depending on the incoming water quality profile, pretreatment and arsenic effluent criteria.

Factors influencing choices

For POU/POE systems, the menu of practical and cost-effective technologies, and specifically adsorption processes, narrows substantially when considering the following:

- **Arsenic species.** Arsenic occurs naturally in groundwater in two primary chemical forms: arsenate (As V) and arsenite (As III). The predominant species depends on the pH, water quality profile, oxidation reduction condition and other factors.

The primary arsenate species in the pH range of 6-9 is monovalent $H_2AsO_4^-$ and divalent $HAsO_4^{2-}$. Uncharged arsenious acid (H_3AsO_3) is the predominant species of trivalent arsenic found in groundwater.

Why is this important? The oxidized form of arsenic is much more readily removed with conventional treatment

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Questions to consider when choosing an arsenic removal technology

Arsenic species: Which prevalent form of arsenic is in the water? As III or As V? Will the water be oxidized or disinfected prior to adsorption? Can the technology remove As III and As V species?

Arsenic concentration: What is the influent concentration of arsenic? What is the acceptable effluent arsenic level?

Kinetics: Will the technology remove arsenic rapidly from the water and with high enough efficiency to meet the treatment goals given the short contact time of point-of-use and point-of-entry systems?

Flexibility and simplicity: Can the technology be easily packaged, added or adapted to small filtration devices, cartridges and whole-house systems?

Operating adaptability: How will the adsorbent perform in varying water quality profiles including pH, alkalinity and hardness?

Operation and maintenance: How much consumer attention (operation and maintenance) does the technology require? Can the spent adsorbent or cartridge be thrown away or discarded as nonhazardous solid waste? Does it require any chemical addition or regeneration?

Expected life or capacity: How long will the media or cartridge last under normal operating conditions and typical water usage?

Cost: Is the technology affordable to the average consumer in its final form either as a delivered system or cartridge?

Certifications: Has the media or technology been tested or certified under an applicable NSF, Underwriters Laboratories or Water Quality Association standard?

technologies, including most adsorbents. The As III form typically is more resistant to conventional technologies, usually requiring an oxidation or pretreatment step to enhance removal. Because arsenic can be present in either form or combination as it reaches the tap, successful technologies or combinations of treatment must consider both forms.

- **Kinetics.** Adsorption kinetics, or the rate of arsenic uptake, is another critical factor. It is influenced by the surface and pore properties of the adsorbent, e.g., micro- and macroporosity.

Given the relatively compact size of whole-house treatment systems or POU devices, effective adsorbents for POE and POU applications must be very rapid, allowing efficient removal of arsenic to low levels.

Unlike fixed-bed adsorption processes, such as in centralized larger drinking water systems where contact times of five minutes or more are not unusual, the contact time in a POU device is often less than 15 seconds. This presents a much greater challenge for a 90+ percent removal of arsenic from 50 mg/L to less than 5 mg/L.

Adsorption media pretreatment recommendations

pH range	5.5 - 8.5	Turbidity	5 NTU
Hardness	< 500 mg/L as $CaCO_3$ < 30 gpg	Suspended solids	< 5 mg/L
Iron	< 0.5 mg/L	Sulfates	< 300 mg/L
Manganese	< 0.2 mg/L	Silica	< 30 mg/L
Color	None	Sulfur	< 3 mg/L

- **Influent water quality**. Like any technology, the water quality profile plays an important role in proper selection and overall performance. Primary adsorption performance parameters include arsenic concentration, arsenic species, pH and contact time.

Secondary performance factors include the presence and influence of other species that can compete with arsenic adsorption, occupy adsorption sites or foul the media.

The most common competing ions include negatively charged species, such as sulfates, phosphates, silicates and fluoride. Adsorption capacities can vary widely depending on influent concentrations of these parameters.

Also, excess concentrations of iron and manganese, if not properly pretreated or controlled can prematurely foul the media and inhibit arsenic adsorption. The chart below shows typical pretreatment guidelines for adsorptive media.

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- **Application flexibility.** Finding a "one-size-fits-all" approach to arsenic removal in the POE and POU business is probably wishful thinking given the diverse water quality profiles, wide range of flow rates and water usage, presence of competing ions, available space, and cost constraints.

Although they share a common goal, POU solutions will be different from POE solutions given their unique differences. Consumers will need customized solutions to meet the particular geographic needs. One example is in the upper Midwest, where in some counties, naturally occurring arsenic concentrations are 5 to 20 times higher than other parts of the United States. In these cases, a treatment train approach using a combination of technology may be required.

Advances in adsorbent technology

Specialty adsorbents designed to meet this challenge are emerging. One type is an inorganic, high-porosity metal oxide-based adsorption media that can remove the two most common aqueous forms of arsenic. Metal oxides such as alumina, iron, manganese, silica and others can be combined using a process to create hybrid co-particles with enhanced arsenic removal capabilities.

This adsorption media can be employed in a variety of applications and devices to meet the needs of end users. The technology can be incorporated into existing treatment equipment as an add-on; for example, it can be used in a postsoftening step for arsenic removal or as a stand-alone technology.

Like other adsorbents, the materials can be manufactured to specific particle sizes that are adaptable to conventional filter housings, precoat cartridges, pleated nonwoven fabrics and conventional fiberglass POE cylindrical tanks.

For POU applications, the media can be formulated as an active ingredient to carbon blocks, carafes and other devices for achieving multiple functionality where arsenic reduction can be obtained along with other health or aesthetic-related claims.

Momentum and public demand for arsenic treatment solutions are increasing rapidly. Arsenic abatement in POE and POU applications, in contrast to larger centralized drinking water systems, poses some unique challenges that can be met with new advances in adsorbent technology.

Specialty adsorbents offer attractive advantages and flexibility over other technologies that should be seriously considered for meeting the new drinking water treatment regulations for arsenic. □

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