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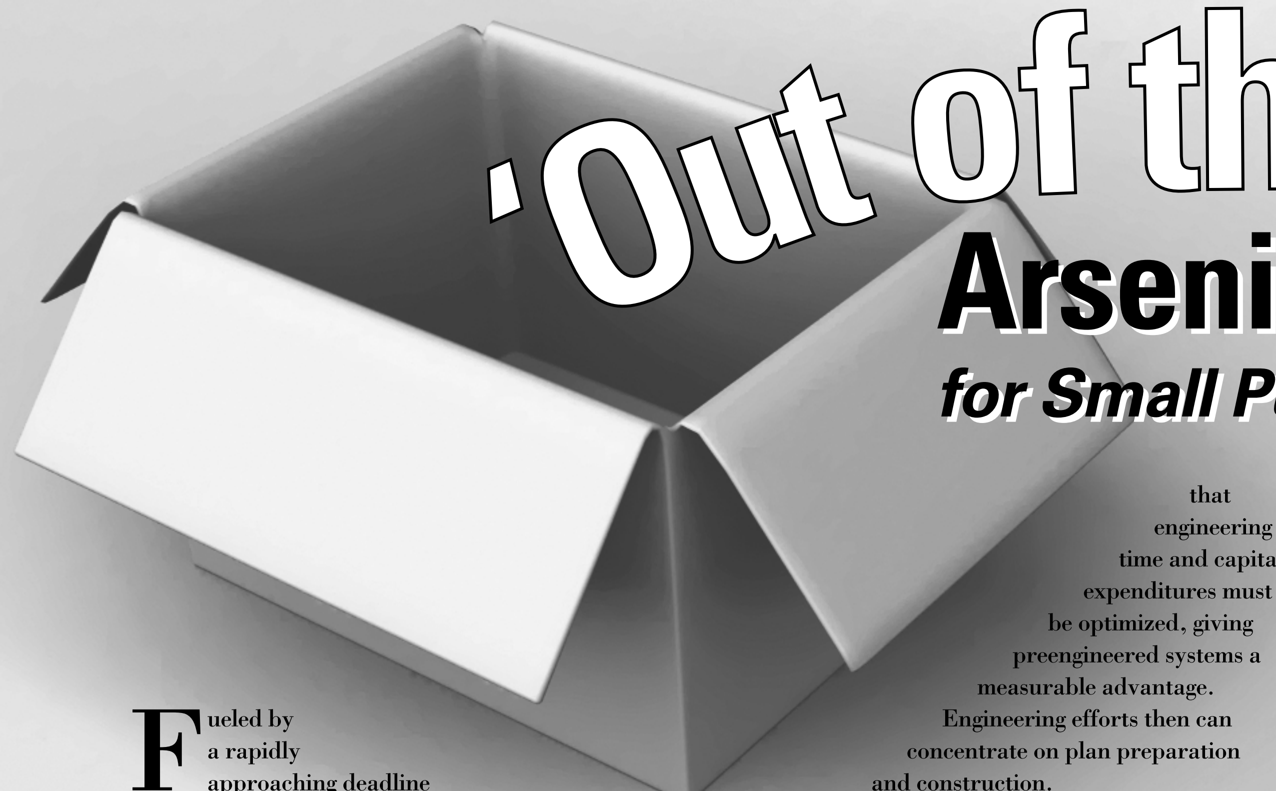
'Out of the Box' Arsenic Treatment for Small Public Water Systems



Fueled by a rapidly approaching deadline to comply with stringent U.S. Environmental Protection Agency (EPA) rules for arsenic in public drinking water, emerging commercial technologies are replacing the "old standards" for small water system (SWS) applications. Within the categories of small community and non-community, non-transient systems, the highest percentage requiring treatment are those with populations of 25 to 500. (See Table 1.) Distinctive needs of these SWS projects in contrast to large community systems dictate that competitive economics, simple operation and low waste production will drive changes in technology and engineering. Some out-of-the-box thinking will be necessary in the shift to provide simpler, packaged or preengineered arsenic treatment systems. These developments will unintentionally alter the traditional role of the engineer by offering more efficient time use for planning and project implementation by including the vendor and EPA as partners in the decision-making process.

Small System Needs

EPA mandated reductions to a maximum contaminant level (MCL) of 10 parts per billion (ppb) arsenic by Jan. 23, 2006, are disproportionately affecting these small and very small systems. Inadequate financial and engineering resources, limited equipment space and local technical operators dictate using the simplest treatment systems possible. Table 2 summarizes some of the challenges faced by smaller systems as they gear up for compliance with the arsenic rule.

For smaller systems, more costly traditional methods of treatment must be supplanted by or, in some cases, coupled with new techniques to provide more affordable, flexible and easily implemented treatment systems with a high degree of reliability. Treatment methods and engineering traditionally have been geared towards systems serving more than 10,000 people. Large municipal systems with greater funding options are capable of designing and operating more complex processes such as reverse osmosis, electrodialysis, ion exchange or coagulation/filtration. Small systems, however, face unique issues that have created momentum in the direction of adsorption-based treatment technologies. Difficulty in obtaining funding means that engineering time and capital expenditures must be optimized, giving preengineered systems a measurable advantage. Engineering efforts then can concentrate on plan preparation and construction.

EPA recognized this need and has responded. Treatment demonstrations are underway to expand best demonstrated available technologies (BDAT), which may be considered by the small system owners. New adsorption-based technology is at the forefront of those replacing conventional BDAT options. As proof of the major role adsorption will play as a dominant treatment category, EPA has chosen adsorption methods for nine of the 12 demonstration sites around the United States. Preliminary results for selected sites will be available beginning in first-quarter 2004.

Advantages of Adsorption Technology

Multiple benefits are realized with an adsorption system. Although several types of adsorption technology have been developed, iron-based media are leading the pack. Using media that are capable of addressing both arsenic III and V at normal pH ranges (5.5 to 8.5) reduces costs of pretreatment and operator involvement since no pH adjustment or media regeneration are required. For example, advantages of using an adsorption process such as granular ferric oxide (GFO) include

- Effectively reducing arsenic III and V without a preoxidation step.
- Efficiency ratings of up to 99 percent removal to treat arsenic less than 2 ppb.
- Effectiveness over varied water chemistry.
- Requiring no high pressure pumps.
- Very low energy consumption.
- Minimal head loss;
- Low water consumption.
- Simple operation.
- Availability of preengineered modular units.
- Easily integrated into any system.

Arsenic specificity and efficiency. High efficiency adsorption can effectively reduce arsenic to less than 2 ppb, achieving the required MCL while also reducing other inorganic co-contaminants (i.e., Pb, Sb, Se, V, Mo) present in ppb concentrations. Some iron-based adsorbents also can effectively reduce both forms of naturally occurring arsenic without pretreatment (oxidation), which saves considerable capital and operating expenses. The treatment process does not alter the overall chemical composition of the water being treated. No other ions are exchanged into the potable water supply.

Low pressure requirements. While adsorption systems frequently are housed in ANSI-rated or other pressure vessels, they can operate under gravity flow. Head loss across the media bed is less than 5 psi.

Minimal energy requirements. As there are no high pressure pumps or other high energy consumption operations, adsorption most often will have the lowest operating cost as compared to other technologies.

Low water consumption. Adsorption media (which are not regenerated) do not create a concentrated brine or hazardous waste residual that must be disposed of since no regeneration step is required. Other technologies can waste valuable water resources, in some case as much as 75 percent.

Preengineered systems. Adsorption systems that are preengineered be easily can integrated into existing operations. Equipment compatibility is ensured and products are used that have third-party certifications (e.g., ANSI/NSF International standards) for use in potable water. Low head loss, low energy requirements and chemical stability allow systems to be placed in-line at any point allowed by operational convenience. Due to low pressure requirements, preengineered units can be installed at the well head, down stream of pressure or atmospheric storage tanks and even downstream of chlorination.

Table 1: Arsenic Distribution in Small Water Systems

	Community Water Systems		Non-Transient, Non-Community Water Systems	
Population size	25–100	500–3,300	25–500	500–3,300
Systems exceeding arsenic 10 ppb MCL	1,592	569	902	142
Total affected systems nationwide	2,161	1,044		
Percent of affected systems	73.6%	26.4%	86.4%	13.6%

Source: U.S. EPA Database

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Simple to operate. Iron-based adsorption systems eliminate the need for intensive operator attention and maintenance. In fact, systems consist of simple, down-flow packed beds that require only weekly inspection and periodic backwashing to eliminate grit and fines that may originate in the well. No extensive operator training is necessary.

Finally, permitting is more streamlined when preengineered vendor submittal packages are included as technical validation. Regulatory control is satisfied as application processing is made simpler.

The Engineering Partnership

Achieving these goals requires the coordinated efforts of the local water supply company or system, regulators, consulting engineers, and vendors. The job of providing a reliable and affordable supply of clean water falls to the small water system owner/operator. Consulting engineers represent the interests of the SWS and ultimately, the rate-payer. Often the engineer acts as the focal point and must interpret the regulations, audit the existing distribution system, evaluate commercially available technologies, and recommend the most cost effective strategy.

Packaged, pre-engineered systems reduce the long learning curve for those who must select and implement a strategy from the vast array of arsenic treatment options and efficiencies. The result is better cost options for the water system and more effective time utilization for the engineer. Vendors having strong technical expertise are able to work closely with consulting engineers and regulators whose approval must be gained in order to proceed.

A partnership between the small water system, engineer and vendor benefits all parties with ease of implementation. Table 3 presents a flow chart of a traditional engineering approach compared to a more rapid or streamlined approach that may become more prevalent for arsenic treatment utilizing packaged adsorption systems. Duplicate efforts are avoided and costs reduced for the end user. This cost control may tip the balance between compliance and bankruptcy for the SWS. At a minimum, it will reduce time, money, and perhaps ease the pain of the process.

Engineers are finding that adsorption systems better serve their customer, the SWS. With simpler equipment and operations, process selection is faster. Less detailed engineering is required because "plug and play" arsenic adsorption systems are compatible with a variety of existing plan configurations.

Because EPA demonstrations to validate technologies as BDAT are national in scope, work is shifting from less piloting and study phases to greater emphasis on implementation. These evaluations also will streamline the decision tree or selection process and provide confidence that is directly translatable into cost savings for the small water system.

Table 2: System Characteristics and Issues

	Public Municipal Water Systems	Small Water Systems
Category	Municipalities, utility districts, towns, cities	*Small community systems:* small towns, water supply companies, rural water districts, tribal systems, mobile home parks, home owner associations *Non-transient, non-community systems:* private systems, schools, factories, institutions, shopping centers
Size	> 10,000 people	*Small:* 500 to 9,999 people *Very small:* < 500 people
Funding	Bonds, state/federal revolving funds, USDA, rate payers	*Public systems:* some state revolving funds, rate payers *Private systems:* loans, private financing
Experience	Existing treatment plants	Little or no previous treatment experience
Operations	Adequately trained operators	Shortage of trained operators familiar with treatment processes
Chemical Handling	Most have trained personnel familiar with chemical handling	Unfamiliar with hazardous chemical handling
Disposal Options	Hazardous or non-hazardous sanitary sewer available	Non-hazardous, sewer may not be available
Space	Larger enclosed well houses or buildings for equipment	If building exists, little to no room for treatment equipment
Engineering	On-going, comprehensive	On-demand, project specific, often no designated engineer due to insufficient resources or need

Meeting the Customers' Needs

At the end of the day, success for the SWS will be judged by meeting the new MCL and other desired performance objectives and satisfaction of the end user and individual rate-payer. Yes, providing safer drinking water ultimately will impact the pocket books of the end users. The arsenic rule is no exception. However, the outcome can be a win-win for the parties if the success criteria are met. These criteria are easy to understand, but more challenging to satisfy.

- Safe drinking water
- Reliable supply
- Reasonable cost

New commercial adsorption technologies are forging an encouraging pathway for what normally would be considered an intimidating, if not daunting, task of complying with the new arsenic rule. Like the best available technologies, roles of the parties involved are changing as well to adapt to the special needs of small systems, who are under-resourced and in need of help. With all the regulatory developments, education, training and media coverage over the past two years, there clearly is an unparalleled awareness. However, education gaps still remain to be filled. The irony is that the facilities (systems) that will be impacted the most are the ones with the least access to financial resources and assistance. It will take some out-of-the-box actions by all parties to meet the special needs of these small utilities and public water systems as they navigate through these challenging waters. WQP

References

1 Gilles, Gregory C. "Arsenic compliance: POU vs. centralized treatment for small public water systems," *Water Technology*, September 2003.

2 Washington State Dept. of Health, "Guidance Document: Arsenic Treatment for Small Water Systems." March 2003.

3 U.S. EPA, "Complying With the Revised Drinking Water Standard for Arsenic: Small Entity Compliance Guide." August 2002.

Table 3: Parallel Decision Flow Chart

Traditional Role	New Roles			
Engineer/Consultant	**Small Water System**	**Engineer/Consultant**	**Vendor**	**State/County Regulator**
Detailed review of treatment options and costs	Determine compliance status, options	Retained to review treatment options and costs	Review site profile for applicability; present conceptual treatment approach	Review U.S. EPA-sponsored demos and results, new BDATs; education/training on arsenic
Prepare detailed process and equipment specification docs	Identify treatment goals, site profiles	Provide appropriate drawings/submittals to complement vendor package submittals; PE certifications	Capitol and operating cost proposal submitted with performance predictions	Identify key checklist items for permitting and submittal
Pilot testing and analysi	Seek funding	Conduct pilot testing if sufficient data gaps exist to predict performance	Implement small-scale, packaged pilot program if necessary prerequisite	Oversee/review pilot testing data
Lengthy bidding process, funds acquisition	Seek funding, determine/verify available funding	Compile capital, operation and long-term O&M costs; competitive bidding as applicable	Team with installer for turnkey installation	Plan and submittals review
Permits, construction oversight	Implement project	Analysis and report	Implementation analysis and reporting	State approvals

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