A New and Cost-Effective Arsenic Removal Technology Paves the Way for a More Stringent Federal Arsenic Standard

In drinking water supplies, arsenic poses a threat to human health because it is a known carcinogen. In 2001, the U.S. Environmental Protection Agency (EPA) lowered the maximum contaminant level (MCL) for arsenic in drinking water from 50 parts per billion (ppb) to 10 ppb, where it remains today. New Hampshire and New Jersey are the only states that have gone a step further and reduced their MCLs down to 5 ppb.

EPA's decision to hold the MCL level at 10 ppb stems from the fact that the best available treatment technologies (BATs) typically have had very high investment and operating costs, making it prohibitive for many water utilities to treat down to levels below 10 ppb.

In 2018, the World Health Organization stated that "Every effort should be made to keep arsenic concentrations as low as reasonably possible and below the guideline value of 10 ppb when resources are available."

Currently, EPA is reviewing its MCL recommendations for arsenic.

"The industry is in dire need of a simple, economical and effective treatment solution for arsenic and Aqua Metrology Systems [AMS] believes it has found this solution — the SafeGuard™ H20 arsenic treatment system" said Vladimir Dozortsev, senior product manager for AMS. "With this new innovative technology, AMS believes more stringent regulations can be enacted to further reduce this toxic element in our nation's drinking water and protect our citizens."

Treatment Technologies

AMS has developed a list of comparative characteristics (Table 1) that can be used to evaluate arsenic removal treatment processes that, when considered altogether, paint a picture of overall system effectiveness.

Removal efficiency and costs are the driving factors, but there are others to consider. For example, does a particular treatment technology result in excessive water loss? Arsenic found in groundwater normally presents in two states: arsenite [As(III)] and arsenate [As(V)]; thus, composition of intake water should be taken into account. If its composition leans toward As(III), it will need a pre-oxidation step. Incoming groundwater can have varying pH levels; thus, there may be a need for a pH adjustment before treatment. If there is a high volume of suspended solids in the intake water, pre-filtering will need to occur. The amount of generated waste should be considered as well, as utilities need a plan and system for disposing of that waste. Can a treatment system run on its own or does it need an operator sometimes, or at all times? Also, a system's inertia should be considered — that is, how quickly a system can resume operating at normal levels after a shutdown. This is especially important for small water systems that can be significantly impacted by maintenance shutdowns.

Challenges with Traditional Technologies

Traditional treatment technologies for arsenic include adsorption media (AM), i.e., activated alumina (AA), iron-based media (IBS), coagulation/filtration (CF), ion exchange (IX) and reverse osmosis (RO).

Adsorption media - In recent years, adsorption media treatment technologies using AA and IBS have dominated the market for arsenic treatment. These have proven to be more effective than earlier technologies — yet, they still have high operating costs due to frequent change-outs of the used media and can only economically reduce arsenic levels down to slightly below 10 ppb.

Table 1. List of Comparative Characteristics Developed by AMS to Evaluate Arsenic Removal Treatment Technologies

Removal Efficiency (Performance)	Ability of the treatment system to reduce a contaminant from an initial level to a targeted lower level.
Water Loss (%)	Both raw or/and treated water loss during treatment system operation and maintenance.
Pre-Oxidation	If the selectivity of the arsenic removal treatment technology toward As(III) is poor, pre-oxidation of As(III) to As(V) is critical when both valence states of the contaminant are present.
Pre-Filtering	If suspended solids affect arsenic removal treatment technology performance, as a result, pre-filtration is recommended for water sources where the turbidity exceeds 0.3 NTU.
pH Adjustment	pH adjustment is used to ensure that an arsenic removal treatment technology is working with water that is within an optimal pH range for operational performance. pH adjustment may also be necessary to optimize corrosion control and comply with other regulatory requirements.
Waste Generated	Volume of waste generated by the arsenic removal process to include all liquid and solid waste.
Operator Skill	Skill sets required to operate the arsenic removal technology.
System Inertia	Characterized as a system's ability to reach steady operational conditions and high arsenic removal efficiency after shut-down. The shorter the time period required for treatment process stabilization, the lower the system inertia.
Capital/O&M	Initial investment and ongoing operating and maintenance costs to remove arsenic to <5 ppb.

Additionally, using AA usually requires the extra steps of pre-oxidation, pH adjustments and pre-filtration before treatment even begins. Waste generated from these processes often exceeds the 5 mg/L toxicity limits. When using IBS, a pH adjustment is also likely to be required. Phosphate and silica have been shown to greatly reduce adsorption capacity with iron media as well. Waste generated from the usage of IBS needs to go through a waste extraction test in California and will often fail, thus having to be hauled to a hazardous waste designated landfill. The costs of media replacement in these technologies have averaged around 80% of the total operation and maintenance (O&M) cost. (Wang and Chen, 2011.)

CF, IX and RO - CF processes are effective for the removal of As(V); however, if As(III) is present, pre-oxidation is recommended. Varying pH levels have a significant effect on arsenic removal performance in CF systems, likely leading to pH adjustments before treatment. Post-filtration is often needed as well. CF systems are difficult to operate in a "stop-and-run" manner. Similarly, IX systems also usually require pre-oxidation. Often, suspended solids plug the media in IX systems, increasing headloss and necessitating more frequent backwashing. Inactivity of the IX resin, when the system is inactive, can cause biological growth problems such as scaling and resin swelling and fouling.

RO systems are pressure-driven and relatively insensitive to pH levels; however, a high rate of membrane fouling often causes a decline in arsenic rejection and water recovery. Membrane cleaning is difficult and costly. RO treatment often results in levels of low alkalinity, which in turn causes corrosion control issues in the distribution system.

In all of these instances, it is feasible to maintain stable system performance and reduce degradation; however, additional measures usually need to be taken that will increase cost and complicate treatment system design.

SafeGuard™ H2O Intelligent Arsenic Treatment System

The SafeGuard™ H2O (SGH2O) intelligent arsenic treatment system generates a tin dioxide mixture in-situ (within the system) and uses this non-toxic, food grade material to absorb the arsenic. This reagent is produced on an as-needed basis through a tightly controlled electrolytic process. This fresh and highly reactive sorbent efficiently removes both As(III) and As(V).
This innovative technology can effectively treat groundwater with varying pH levels, eliminating the need for a costly pH adjustment step. Silica, sulfates, phosphates, fluorides and many other substances that may pose significant interferences for

conventional treatment approaches have a minor to no effect on arsenic removal with the SGH2O system. Additionally, suspended solids present in the source water can be effectively removed by the composite media filter and do not require pre-filtration.

As for system inertia, the SGH2O system generates and uses its treatment mixture on-demand. There are minimal treatment process steps and hardware used, contributing to the system's simplicity. The technology's online monitoring capability allows for high treatment process automation as well as quick shutdown and restart; therefore, the risk of damage to system hardware during stagnation periods is minimal. This is a feature unique to the SGH2O technology and is not available with other commercially available arsenic removal systems. The system also has a backwash water reuse feature, resulting in much less water loss than other technologies.

The stannous reagent generator within the system has a modular and flexible design that can be scaled to any size. Depending on treatment size needs and site requirements, a generator can be designed to operate unattended for up to several weeks. Table 2 provides a quick snapshot of traditional arsenic treatment technologies compared to the SGH2O process.

Table 2. Comparative Characteristics and a Review of Arsenic Removal Treatment Processes

Parameter	Treatment Process					
	SAFEGUARD H2O™	IX	AA	IBS	CF	RO
Performance	High	Med-Low	Low	Low	Low	Med-Low
Water Loss	Low	Low	Low	Low	Med	High
Pre-Oxidation	No	Yes	Yes	Yes	Yes	Likely
Pre-Filtering	No	Yes	Yes	Likely	Likely	Yes
pH Adjustment	No	Likely	Likely	No	Likely	No
Waste Generated	Low	High	Med/High	Med/High	High	High
Operator Skill	Low	High	Low	Low	Med	Med
System Inertia	Low	High	High	High	Med	High
Capital/O&M	$/$	$$$/$$	$$/$$$	$$/$$$	$$/$$$	$$$/$$$

SGH2O also features AMS' proprietary, continuous, real-time monitoring of contaminant levels of influent and effluent to ensure optimal treatment and compliance with regulatory and operational targets 24/7/365. Data generated from the onboard arsenic monitoring system help drive a highly accurate remediation process by ensuring reliable reagent dosing control through manipulation of site-specific process parameters.

"The development and commercialization of SafeGuard H2O is poised to displace traditional systems, given the technology's proven ability to eliminate arsenic and drastically reduce the cost of removing the toxic contaminant," Dozortsev said.

"AMS has done a lot of work to prove that SafeGuard H2O can virtually eliminate the presence of arsenic at a very economical cost compared to the alternative treatment technologies which were struggling to even get down to those levels," Dozortsev said. "There is no argument technically and economically now not to have an arsenic regulatory limit that is well below 3 ppb, certainly well below where it is today. The technology is available, it's proven, and it would have a tremendous positive impact on human health to virtually eliminate arsenic from the water to which many people are exposed."

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