U.S. Environmental Protection Agency
Environmental Technology Verification Program
ETV

Arsenic Treatment Technologies

The U.S. EPA Environmental Technology Verification (ETV) Program's Drinking Water Systems (DWS) Center, operated by NSF International under a cooperative agreement with EPA, has verified the performance of twelve technologies for removing arsenic from drinking water.[1] The ETV Program has focused on verifying drinking water treatment technologies that are designed for small system applications.

Technology Description and Verification Results

The ETV Program verified that most of the technologies reduced arsenic concentration to an average of 5 parts per billion (ppb) or less, and many of them reduced arsenic levels to the minimum detection limit of 1 to 2 ppb. The verified technologies include examples of four different technology classes:

Coagulation/Filtration is a traditional treatment process that adds a chemical coagulant (typically ferric sulfate or ferric chloride) to contaminated water. The coagulant modifies the physical or chemical properties of dissolved or suspended contaminants so that they settle from solution by gravity or can be removed by filtration.

Adsorptive Media processes pass contaminated water through a bed of solid media on which the contaminants are adsorbed.

Reverse Osmosis is a treatment process traditionally used for desalination of brackish water and sea water. Reverse osmosis is capable of separating dissolved organic compounds and ions from water by maintaining a pressure gradient across a membrane with a very small pore structure.

Ion Exchange is a treatment process in which the arsenic ion (such as arsenate, AsO_4^{3-}), is removed from solution by exchange with a different ion associated with a solid ion exchange media.

Table 1 is a list of verified arsenic treatment technologies. Verification reports may be found at http://www.epa.gov/etv/verifications/verification-index.html.

Arsenic and Its Regulatory Background at a Glance

Arsenic occurs naturally in rocks, soil, water, air, plants, and animals. It can be released into water, including drinking water, through natural processes such as erosion, or through human actions, including agricultural applications (fungicides or rodenticides), mining, or disposal of arsenic-laden consumer products (wood preservative, paints, dyes, soaps, and semiconductors). Studies have linked long-term exposure to arsenic at various levels in drinking water to cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate. Non-cancer effects of ingesting arsenic include cardiovascular, pulmonary, immunological, neurological, and endocrine (e.g., diabetes) effects.

In January 2001, based in part on the National Academies of Science recommendation and to protect consumers against the effects of long-term, chronic exposure to arsenic in drinking water, EPA set a new drinking water standard for arsenic at 10 ppb with compliance by all public water systems required by January 2006 (66 FR 6976). The new standard applies to about 74,000 water systems, approximately 5% of which will have to take actions, such as installing treatment equipment, to meet the new standard. Of the systems that will need to take action to meet the new standard, EPA estimates that 97% (or about 3,900) are small systems that serve fewer than 10,000 people each. The ETV-verified technologies are designed for use by these small systems.

Verified Arsenic Treatment Technology

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[1]The ETV Program operates largely as a public-private partnership through competitive cooperative agreements with non-profit research institutes. The program provides objective quality-assured data on the performance of commercial-ready technologies. Verification does not imply product approval or effectiveness. ETV does not endorse the purchase or sale of any products and services mentioned in this document.

Table 1. Verified Arsenic Treatment Technologies	
Technology Name	Technology Description
Pall Corporation Microza® Microfiltration System	This technology is based on chemical coagulation, mixing, and microfiltration with no intermediate solids separation process. The Microza System includes pretreatment with sodium hypochlorite to oxidize any arsenic (III) to arsenic (V) and iron present in the water supply.
ORCA Water Technologies KemLoop 1000 Coagulation and Filtration Water Treatment System	The ORCA process is based on chemical addition with mixing in a proprietary mixing loop to optimize coagulation, and granular media filtration with no intermediate solids separation process. The KemLoop System includes pretreatment with sodium hypochlorite to oxidize any arsenic (III) to arsenic (V) and iron present in the water supply.
Delta Industrial Services, Inc. CampWater Porta-5 System	The CampWater System is a coagulation/filtration technology that utilizes ozone to oxidize naturally occurring iron to form a ferric hydroxide solid, which is filtered directly without additional flocculation, solid separation, or clarification.
Kinetico, Inc. Macrolite® Coagulation and Filtration System, Model CPS100CPT	This system is a coagulation/filtration technology that utilizes sodium hypochlorite and ferric chloride and a proprietary ceramic filtration material.
Watermark Technologies, LLC eVOX® Model 5	eVOX is a coagulation/filtration technology that utilizes sodium hypochlorite and ferric chloride to produce an insoluble large particle hydroxide precipitate that can be removed using a simple non-proprietary media filter or clarification.
ADI International Inc. Pilot Test Unit No. 2002-09 with MEDIA G2®	The ADI system is an adsorptive media technology that utilizes a proprietary media consisting of an inorganic, natural substrate upon which iron (ferric hydroxide) is chemically bonded.
Kinetico Inc. and Alcan Chemicals Para-Flo™ PF60 Model AA08AS with Actiguard AAFS50	Para-Flo™ is an adsorptive media technology that utilizes a proprietary granular iron-enhanced activated alumina media.
Hydranautics ESPA2-4040 Reverse Osmosis Membrane Element Module	These are reverse osmosis technologies designed to reject dissolved salts and ionic solids, such as arsenic, sodium, chloride, and other dissolved materials from drinking water.
KOCH Membrane Systems TFC® —ULP4 Reverse Osmosis Membrane Module	
Watts Premier M-Series M-15,000 Reverse Osmosis Treatment System	
Basin Water High Efficiency Ion Exchange Treatment System	The Basin Water System is an ion exchange process in which a solution containing the ion (such as arsenate, $HAsO_4^{2-}$) is passed through an ion exchange resin and exchanged with a similarly charged ion (such as chloride, Cl^-) attached to the resin.
Advance Remediation Systems Arsenic Removal System CFU-5	This technology involves on-site generation of chemical coagulants with flocculation and filtration.

Selected Outcomes of Verified Arsenic Treatment Technologies

The market for ETV-verified arsenic treatment technologies includes small drinking water systems that need to install or modify treatment processes to comply with the 10 ppb arsenic standard. ETV's analysis indicates that 3900 small systems fall within this category. If 25% of these systems (980 systems) decide to use an ETV-verified technology to help them comply with the new standards, ETV estimates that:

- The ETV-verified arsenic drinking water treatment technologies would prevent up to 4.8 cases of lung and bladder cancer and up to 2.6 deaths from these cancers per year
- The technologies would result in economic benefits of up to $17.1 million per year due to the prevention of the above cases of lung and bladder cancer
- Between $2.0 and $14.7 million in pilot testing could also be saved if ETV data are used to reduce pilot testing requirements.

Twenty-five states reportedly use ETV verification data to reduce the frequency and/or length of site-specific pilot tests for drinking water treatment. States such as Utah are willing to use ETV verification data to support permitting and approval decisions.

References

U.S. EPA, 2006. ETV Case Studies: Demonstrating Program Outcomes. EPA/600/R-06/001. January. (Primary source)

U. S. EPA ETV, http://www.epa.gov/etv/.

U.S. EPA Arsenic in Drinking Water, http://www.epa.gov/safewater/arsenic/.

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