DE NORA
our research - your future

How To Weigh Your Options For Arsenic Removal

Arsenic is among the most well-known, and most feared, drinking water contaminants. Finding its way into water supplies through natural and manmade avenues, the carcinogen poses particular obstacles to those operations responsible for treating it.

To get a grasp on those obstacles and the technologies that can best overcome them, Water Online spoke with De Nora Water Technologies. The technology provider offered insight on where arsenic comes from, how operations can determine the right treatment solutions for them, and what it takes to make the most of these solutions over the long run.

How does arsenic reach source water and contaminate it?

Arsenic occurs naturally in rocks and soil before being released into water supplies through erosion. Certain industrial practices also have the potential for releasing arsenic into the environment. A byproduct of the industrial treatment process, arsenic is discharged into the groundwater during the production of paints and dyes, metals, soaps, drugs, and wood preservatives, and can also be traced to deep-water brines produced from gas and oil well drilling.

Why is it difficult to remove arsenic from drinking water supplies?

Because it is soluble and dissolved in water.

What health threat does arsenic pose if consumed?

Inorganic arsenic compounds such as those found in water are highly toxic. The immediate symptoms of acute arsenic poisoning include vomiting, abdominal pain, and diarrhea. These are followed by numbness and tingling of the extremities, muscle cramping, and death, in extreme cases.

The International Agency for Research on Cancer (IARC) has classified arsenic and arsenic compounds as carcinogenic to humans and has also stated that arsenic in drinking water is carcinogenic to humans.

Long-term effects of ingestion of inorganic arsenic include developmental effects, neurotoxicity, diabetes, pulmonary disease, and cardiovascular disease. Arsenic-induced myocardial infarction can be a significant cause of excess mortality. Arsenic is also associated with adverse pregnancy outcomes and infant mortality, with impacts on child health, and there is some evidence of negative impacts on cognitive development.

What options are on the market for removing arsenic from potable groundwater sources?

There are various options available, ranging from ion exchange, activated alumina, reverse osmosis, coagulation/filtration, and adsorption. Adsorption is a continuous process conducted at a specific flow rate or velocity, normally about 7 gpm/ft2, downward through a fixed bed adsorber. Empty bed contact time (EBCT), which dictates the amount of water resident within the bed required

to effect complete arsenic adsorption, is another key process parameter.

What makes adsorption an ideal technology?

Adsorption is a simple, passive process with a relatively low cost. For example, coagulation/filtration has higher initial capital costs and is more labor-intensive. It is more complex than adsorption, a key concern for utilities without centralized treatment plants. However, coagulation/filtration can prove to be an effective solution when treating for high levels of multiple contaminants.

One of the advantages of iron adsorption is the predictability of the breakthrough. Comparatively infrequent monitoring of performance can give optimum performance and both arsenate and arsenite are removed.

How does the SORB 33® process work? What types of media are involved?

The De Nora SORB 33® arsenic removal system is a fixed-bed adsorption system that uses a granular ferric oxide media, Bayoxide® E33, for the adsorption of dissolved arsenic. The system employs a simple "pump and treat" process that flows pressurized well or spring water through a fixed-bed pressure vessel containing the media where the arsenic removal occurs. Both arsenite (arsenic III) and arsenate (arsenic V) oxyanions are removed from water via a combination of oxidation, adsorption, occlusion (adhesion), or solid-solution formation by reaction with ferric oxide ions.

What sizes and configurations are available?

De Nora SORB arsenic removal solutions are available in a range of sizes and configurations, from 4-feet to 14-feet diameter per single vessel (multiple vessels can be used together), treating a range of flow rates depending on water quality considerations and employing various process configurations including parallel flow, with bypass and blending, or series flow.

How is the optimal size and configuration determined?

Configuration of a water utility's arsenic treatment system can best be answered by first prioritizing that utility's water treatment design philosophy, its water quality (aresenic level), and the state's design criteria for water treatment systems. The key criteria are:

1. Capital available for arsenic treatment;

2. Available footprint, or space, for installation;

3. The level of redundancy required if an adsorber is taken out of service;

4. State rules regarding treatment bypass and blending;

5. The trade-off between capital and operating costs for treating high arsenic waters;

6. Optional centralized treatment

What are the considerations and options for configurations that are available for adsorption systems?

The simplest configuration for adsorption processes is parallel flow between two or more adsorbers. The most economical configuration is parallel flow with bypass and blending.

Since Bayoxide® E33 media will adsorb arsenic to levels of < 3 µg/L throughout most of the adsorption cycle, some water can be bypassed via flow control and blended with treated water to an average arsenic level of 1 to 2 µg/L below the 10 µg/L MCL. This extends media life, reducing operating costs. It also allows for smaller adsorber vessel designs due to reduced loading rates. Bypass and blending is recommended for waters with arsenic levels of < 25 µg/L.

Treatment through two adsorbers in series flow configurations ("lead/lag") is recommended for waters with high arsenic levels (> 30 µg/L). The media's arsenic adsorption capacity can be optimized by allowing the first "lead" bed of media to continue to adsorb arsenic past the 10 µg/L MCL while the second bed acts as a polishing, or "lag," adsorber. This is possible because the arsenic breakthrough curve is gradual, even when the treated water exceeds 10 µg/L of arsenic. When media is changed out in the first adsorber, the second one becomes the lead adsorber while the first one is placed in the lag position. The media can adsorb up to 40 percent additional arsenic in this configuration when compared with proportional operating costs for parallel flow. These savings can offset the more expensive capital costs, which can be up to 70 percent greater than for parallel flow design.

"(N + 1) redundancy" parallel flow configuration uses three or more adsorbers designed so that one adsorber can be taken out of service for backwash, etc., while the other adsorbers continue to treat the full well capacity. The adsorbers in service treat water above the minimum EBCT contact time and below the maximum loading rates. Some state regulations require this level of treatment system redundancy.

Optimization of the series flow and (N + 1) redundant designs is the sequencing configuration. Three or more adsorbers are designed with a valve and piping manifold that allows for parallel, N + 1, simultaneous parallel, and series flow, and parallel flow with simultaneous backwash. This configuration optimizes media capacity while minimizing capital costs and area requirements.

How can the media life be optimized?

Media life typically ranges from six months to six years, depending on water quality levels. Media usage can be optimized in multiple parallel flow adsorber systems via staging. The media lifecycle for each adsorber is staggered such that one is operating in the latter stages of its life while others are operating at earlier stages of media life. The adsorber with the oldest media can operate to 12 to 14 ppb arsenic breakthrough because its water is blended with other adsorbers discharging water with arsenic in the 2 to 6 ppb range. The treated water from the adsorbers contains an arsenic level of about 8 ppb.

Although systems are usually simple to operate, owners may consider the additional backup of service agreements to support the most effective operation of the system to extend media life and undertake media change-out when required.

What do you see in the future of adsorption systems for arsenic removal?

The innovation team at De Nora is continually seeking process improvements and are in a constant state of development to offer our customers even greater efficiencies. ■