

# Arsenic Removal by Regenerable Anion Resin

By Frank DeSilva & Scott Blumhof

**I**n January 2006, the U.S. Environmental Protection Agency started enforcing the new arsenic limit of 10 parts per billion (ppb) in drinking water. The previous limit was 50 ppb. Since that date, there has been a flurry of activity in bringing selective arsenic media to the market.

Most of these selective media are based on adsorption principles where the arsenic is captured onto iron oxide. The media currently available include granular ferric oxide, granular ferric hydroxide and hybrid anion resins that contain iron oxides within the gel phase of the resin.

The removal of arsenic by these media follow the rules of iron chemistry, and adsorption onto the iron oxide is affected by several variables. The water parameter that has the biggest impact on the capacity throughput and effectiveness of iron-based media is pH.

### Arsenic and pH

At a neutral pH level of 7, the media have extremely high throughput capacity for arsenic in the form of arsenate, and low to moderate capacity for arsenite. It is always a good idea to have the inlet water arsenic speciated to identify the arsenic as arsenite (As+3) or arsenate (As+5). Oxidize as necessary upstream of the unit to convert the arsenite to arsenate.

As the pH levels rise in water, the constituents that can interfere with arsenic adsorption include silica, phosphate, selenium and vanadium. The pH effect at levels higher than 8.5 can be drastic, often reducing the capacity of a hybrid media down to only the capacity that is available on the ion exchange resin sites, which is about 2,000 bed volumes. Compare this with a throughput capacity for arsenic at a neutral pH of more than 75,000 bed volumes. (To convert bed volumes to gallons per cubic foot, multiply bed volumes by 7.48.)

Figures 1 and 2 demonstrate the tremendous effect that an elevated pH has on throughput. The throughput realized in Figure 1 at a pH of 6.8 of 517, 143 gallons per cu ft is drastically reduced to 25,259 gal per cu ft when the pH is 8.5, and all other parameters stay the same, as shown in Figure 2.

### The Dealer's Solution

Water treatment dealers need an economical solution for treating arsenic-laden waters when the pH

levels are at the high end of the drinking water scale. The selective arsenic media are several times the cost of standard anion resin, and if the throughput capacity is not realized to justify the additional cost, it is worth looking at an old tried-and-true method of arsenic removal—brine-regenerated strong base anion resin.

The two types of anion exchange resins commonly used today are Type 1 and Type 2 strongly basic anion exchange resins. Both are used to remove sulfates, nitrates, arsenic and alkalinity.

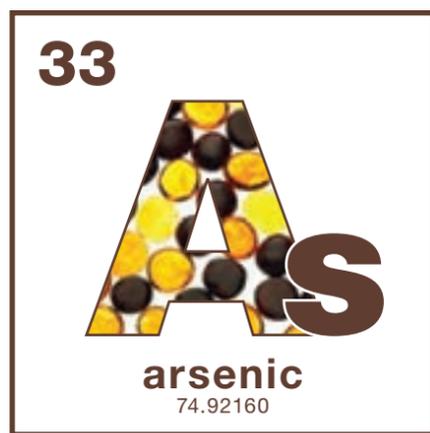
Type 1 resin derives its ion exchange capabilities from the trimethylamine (TMA) group. Type 2 resin derives its functionality

from the dimethylethanolamine (DMEA) group. It should be noted, however, that the TMA used in Type 1 anion resins is what can cause a fishy odor in water under certain alkaline conditions. Some water treatment professionals prefer to use Type 2 anion resins for drinking water applications because they have a much lower potential for contributing a fishy odor to water. The capacities of the two resins are virtually identical in brine-regenerated systems.

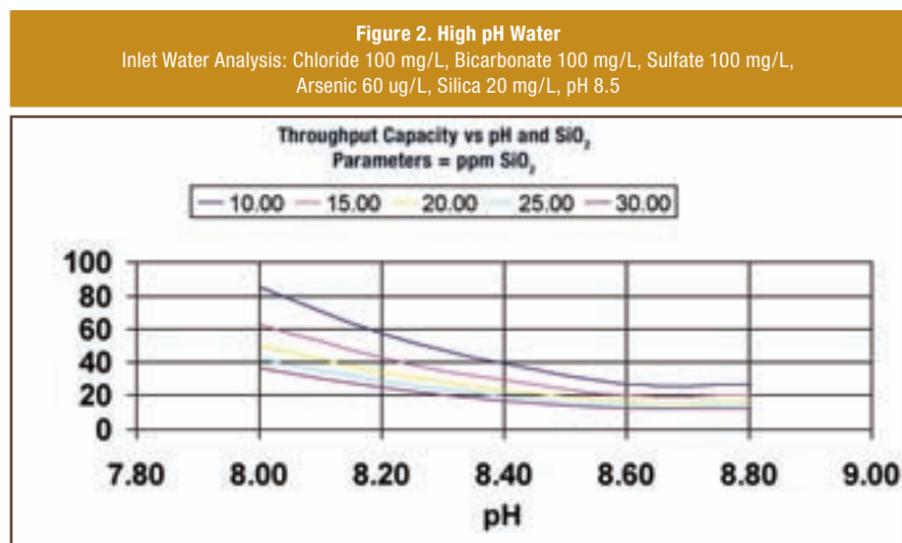
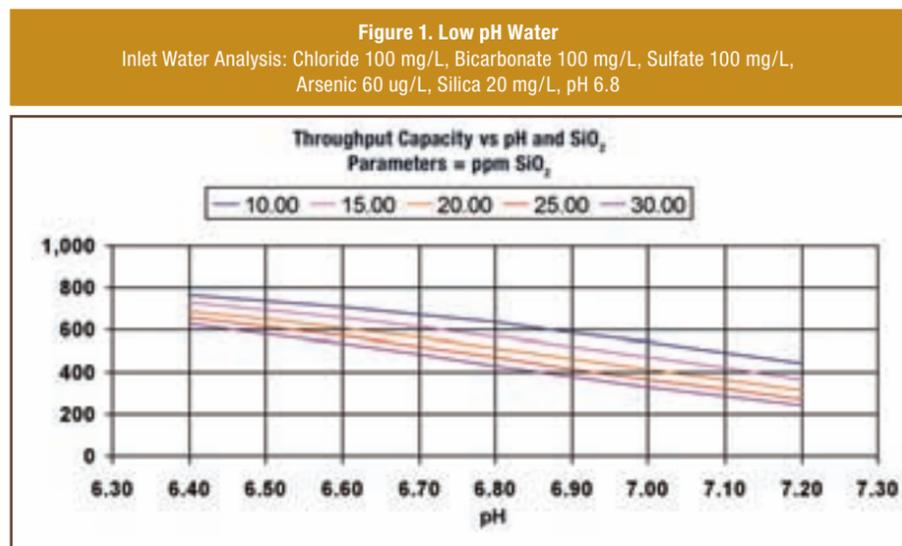
The relative order of affinity of these strong base anion resins for some common ions in drinking water is:

**Sulfate > Arsenate > Nitrate > Chloride > Bicarbonate > Fluoride**

Looking at these affinity relationships, you can see why the standard anion resins are limited in most applications by the amount of sulfate in the water. Sulfate is practically the strongest held anion, and it is almost always present in much higher amounts than the ions that we are trying to remove in drinking water



Effective arsenic removal applications for water treatment



treatment, such as fluoride, nitrate, arsenic, selenium, chromium, etc.

### The Chloride Form

When the anion resins run in the salt form, chlorides initially replace all anions. The effluent sulfates will be near zero throughout the run.

Bicarbonates will be exchanged for chlorides in the first part of the run and then pushed off the resin in the latter part of the run. In normal drinking water concentrations, because sulfate has a higher affinity for the resin than the other anions, the sulfate occupies the top portion of the bed and the arsenate and nitrate (if present), which have the second and third highest affinity for the resin, take the next position.

On over-exhaustion, the sulfate will displace the arsenic so that the arsenic concentration will rise sharply to a level in excess of the arsenic level in the raw water—a phenomenon called dumping. It is extremely important to understand this operational concern: If the unit is overrun, the end user will have high levels of arsenic in their drinking water. Appropriate safeguards must be accommodated in the design of the system, such as:

- Ensure the design water analysis is accurate;
- Downgrade throughput capacity predictions by at least 25%;

- Install two tanks in series using the lead-lag philosophy;
- Make sure that the customer realizes the importance of maintaining the unit and keeping the brine tank full; and
- Consider supplying the unit(s) on a service-exchange basis.

The pH level will be reduced during the first part of the run due to the removal of alkalinity and increased above the influent pH once bicarbonates (alkalinity) begin to leak. Chlorides in the effluent will be equal to the sum of  $\text{SO}_4$  and the other anions present during the first part of run and will be equal to  $\text{SO}_4$ , Cl, and As during the latter part of the run, after the alkalinity has broken through.

Because the anion unit is salt regenerated, materials of construction may be the same as for a water softener. Also, because no caustic is used for regeneration, the influent to the unit does not necessarily need to be softened. Some chloride cycle anion units, however, can have scaling problems from the presence of hardness, especially in higher pH conditions, so a softener upstream of the anion unit is a plus.

The resin is typically regenerated with dilute brine, usually at 10 lb per cu ft. When operated in the chloride cycle (sodium chloride regeneration),

the resin will not exchange for  $\text{CO}_2$  or silica. Recommended service flow rate is 3 to 5 gpm/cu ft.

### The Treatment Process

Water treatment dealers can consider brine-regenerated anion resin for arsenic removal applications where appropriate. This treatment process can be economical when the pH of the water to be treated is relatively high and the influent sulfate is not present in amounts that would negatively impact throughputs.

In all arsenic removal applications, as well as other applications for removing emerging contaminants such as uranium, chromate, radium, etc., where the consequences of the high levels of the contaminant in water are health related, it is recommended that an accurate water analysis be performed and the results reviewed by your media supplier. *wqp*

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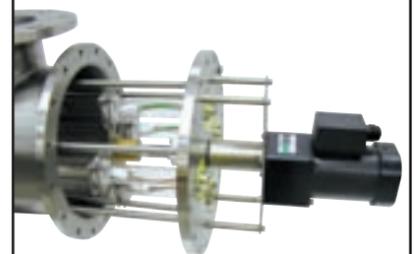
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