

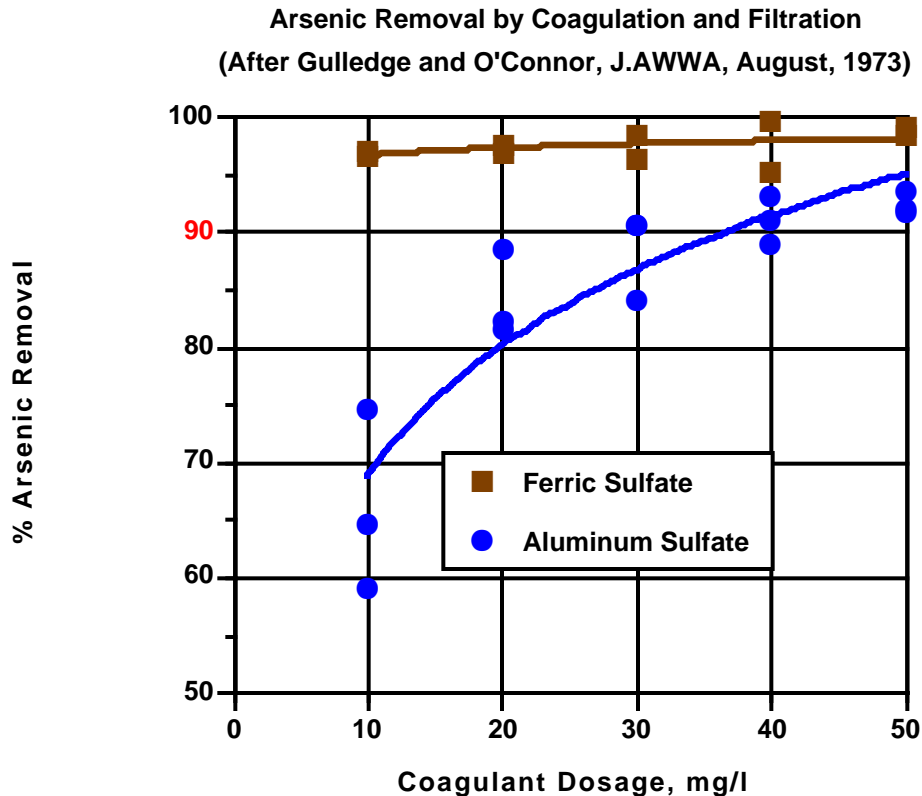
Arsenic in Drinking Water

Part 4. Arsenic Removal Methods

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Conventional Treatment - Precipitation with Iron, Aluminum

As early as 1973, prior to the start of the USEPA review of the arsenic standard, arsenic removal studies (Gulledge and O'Connor) demonstrated that arsenic could be readily removed to a high degree (> 90%) by conventional water treatment processes utilizing chemical coagulants, such as iron and aluminum. Iron precipitates were found to be particularly effective in adsorbing and co-precipitating arsenic. Subsequent studies have repeatedly confirmed effective removal by precipitation with iron. As a result, where arsenic removal is practiced, it is generally removed along with the removal of iron. Where dissolved (ferrous) iron is absent in the source water, the addition of an iron salt, followed by iron hydroxide precipitation, is used to remove arsenic with great efficiency and at low cost.



Alternate Arsenic Removal Techniques

Less common arsenic removal techniques include anion exchange and adsorption on activated alumina. Both produce arsenic-bearing brines that may require evaporation for volume reduction prior to ultimate disposal. While suitable for small, household treatment systems where the medium is replaced on a prescribed schedule, greater process control and more comprehensive monitoring would be required to maintain continuously effective arsenic removal using these processes in a community water treatment facility.

Even more costly water treatment techniques, such as reverse osmosis, have been used to develop some estimates of the potential economic impact of a national program of arsenic removal. Membrane separation processes might prove feasible if other water quality objectives, such as the reduction of dissolved solids and nitrate ion concentrations, were required in addition to arsenic removal.

USEPA Arsenic Removal Study: Plant A Results

Starting in 1998, USEPA began monitoring arsenic removals at a central Illinois water treatment plant, identified only as "Plant A." The water system for this community has treated ground water for the removal of iron and manganese since 1970. The USEPA monitoring results showed that, unintentionally, but incidental to the treatment provided for iron removal, arsenic concentrations were reduced from 20.3 µg/l to less than 3 µg/l, the lowest arsenic standard considered by USEPA. The incremental cost for the highly effective (91% average) removal of arsenic at Plant A was zero. This utility, with three identical iron removal plants, has been effectively removing arsenic from its ground water for more than 30 years. In the Midwestern U.S., thousands of iron removal plants use essentially the same standard process as Plant A.

Disposal of Arsenic-bearing Treatment Plant Residues

As would be expected, the arsenic removed at Plant A was recovered along with the iron hydroxide sludge from filter backwashing. This has created a secondary concern over the practice of land disposal of the treatment plant residues and raised the question of whether the Plant A sludge required regulation as a hazardous waste. A USEPA Toxicity Characteristic Leaching Procedure (TCLP) test indicated that the sludge from Plant A was not readily leached and should be accepted by nonhazardous landfills.

The results from the Plant A study indicate that co-precipitation of arsenic with iron provides an inexpensive means for effectively removing arsenic from ground water. This treatment procedure also minimizes the costs of disposing of the treatment plant sludge residues.

Implications for the Feasibility of Meeting More Stringent Arsenic Standards

As of June, 2001, USEPA has cited a \$200 million annual cost to municipalities, states and industry of meeting the 10 µg/l arsenic standard by 2006. One assumption made is that the cost of meeting still more restrictive

standards would be exponentially greater. This may not be true in the case of arsenic when over 95% removals are being observed even at older, conventional plants not specifically designed for arsenic removal. Still further reductions in arsenic may only require increased iron coagulant dosages and arsenic removal may be essentially independent of the physical facilities required.

It should also be recognized that many of the smaller utilities affected by the arsenic rule may face other MCL violations, often due to the presence of agricultural chemicals, such as nitrite, nitrate and atrazine. These needs might be addressed by providing treatment, nominally, to address another critical health issue. A clinical assessment of small system treatment needs may show that these water utilities require the construction of treatment facilities to meet the requirements of existing regulations, independent of the need to reduce arsenic concentrations.

Arsenic Removal at Albuquerque, NM

Since the groundwater source for Albuquerque, NM contains 52 µg/l of arsenic, treatment facilities are being designed. Following pilot scale evaluation of three options (co-precipitation with iron, anion exchange, activated alumina) co-precipitation of arsenic with ferric hydroxide formed from the addition of ferric chloride was selected. Studies indicated that arsenic concentrations could be reduced to less than 2 µg/l (96% arsenic removal) by the addition of 5 to 22 mg/l of ferric chloride. (This result is consistent with the results shown in the figure above.)

While the treatment plant planned for Albuquerque is more elegant (e.g., skid-mounted microfiltration units, lamella thickeners, recessed plate filter press) than Plant A, the process and the predicted results are essentially the same as that widely used throughout the U.S. for iron removal.

Anion exchange was rejected because it requires the use of large quantities of sodium chloride. The arsenic-bearing brine produced in regenerating the anion exchange resin was classified as a hazardous waste, further increasing brine disposal costs.

The use of activated alumina would require the addition of sulfuric acid to lower the pH of Albuquerque's alkaline water. Final treatment would, then, require the addition of sodium hydroxide to neutralize the treated water. As with anion exchange, arsenic adsorption on activated alumina would generate a brine classified as a hazardous waste.

Not only is the estimated capital cost of an iron precipitation facility lower, but the estimated annual operation and maintenance costs would be 60% of the other alternatives. While a great deal of research has been done in recent years on alternate processes for arsenic removal, little attention was previously focussed on the potential capital and operating costs of these alternatives.

In summary, the technology for the removal of arsenic from many, if not most, community water supplies exists, and is one of the most common processes used in the treatment of both ground and surface waters in the U.S. The incremental costs for the removal of arsenic in those communities already having filtration facilities should represent only a small fraction of the total cost of producing and delivering safe drinking water.

In many cases, where citizens and community leaders have been reluctant or unable to support the cost of

providing treatment to meet existing regulatory requirements, the need for arsenic removal may provide an additional incentive to either provide comprehensive treatment, seek a more secure alternate water source or purchase water from a regional water commission. The latter option is being adopted rapidly throughout the midwestern U.S. as smaller communities recognize the cost implications of meeting health-based regulatory requirements and the significant economic benefits of regionalization of water supplies. Increasingly, in drinking water production and distribution, substantial economies of scale are achieved with the management and operation of larger-capacity water facilities.