Case Study - Arsenic Treatment Technologies
Tucson, AZ

Background: Water Quality Characteristics

Tucson Water serves a population of approximately 600,000 (providing 85% of the Tucson metropolitan area's potable water supply). The system utilizes approximately 190 wells, some of which are operated seasonally to meet the City's peak water demands. The average annual water demand is estimated at 102 million gallons per day (MGD).

Although it is a large system, Tucson Water can be compared to smaller community water systems, since most of its wells serve fewer than 4,000 customers.

Tucson Water has primarily depended on ground water, which is affected by naturally occurring arsenic. The utility has been working with the Central Arizona Project to incorporate a surface water source, so that the higher arsenic ground water can be blended with the low arsenic surface water. By the end of 2003, Tucson Water anticipates utilizing the surface water source for approximately half of its total supply.

Typical Raw Water Quality - Tucson Test Site[1]

pH	7.5
Arsenic (As(V))	0.013 mg/L
Chloride	24.3 mg/L
Fluoride	1.3 mg/L
Iron	<0.04 mg/L
Nitrate (as N)	6.63 mg/L
Silica (as SiO_2)	34.5 mg/L
Sulfate	130.6 mg/L
Total Organic Carbon	0.37 mg/L

[1] Norton, M; Chang, Y; & Kommineni, S. "Evaluation of Micro-Sand-Based Technologies for Arsenic Removal - Ballasted Sedimentation and Metclean™ Process.

Generally, the only existing treatment provided by Tucson Water is disinfection. The utility does provide additional treatment for water utilized from a groundwater clean-up project contaminated with TCE (about 5% of the total annual water usage).

Tucson has not had difficulty complying with the current 0.050 mg/L maximum contaminant level (MCL) for arsenic. The revised 0.010 mg/L arsenic MCL will require the utility to install additional treatment at one of its wells (the sole source of supply for a small isolated service area). In addition, the utility anticipates needing to blend water at a number of wells with higher arsenic concentrations with other low arsenic concentration water supplies.

Pilot Testing

Tucson Water has tested multiple arsenic treatment technologies at two well sites. Most recently, the system simultaneously tested four technologies including:

- Activated alumina (conventional, iron-modified, and high porosity); and,
- Granular ferric hydroxide.

Sponsored by the American Water Works Association Research Foundation (AWWARF), the goal of this pilot project was to test emerging technologies for arsenic removal. This project was one of the first to simultaneously test multiple technologies on a large-scale, year-round basis and was run in conjunction with the pilot testing at the City of Scottsdale's water system.

A skid-mounted apparatus holding four separate, identical fixed-bed columns, was installed at the Tucson treatment site. Each column, operated in parallel, contained 25 gallons of adsorbent media. The flow rate to the skid was 20 gallons per minute (gpm).

Figure 2: Tucson Pilot Testing Unit

Four different proprietary adsorption media were tested:

- Conventional activated alumina;
- Iron-modified activated alumina;
- High porosity activated alumina; and,
- Granular ferric hydroxide.

The goals of the tests were to discover whether the adsorbents would allow Tucson Water to meet the revised 0.010 mg/L arsenic MCL (taking operation and maintenance, labor, and personnel costs into account); test whether there was any seasonal impact on the effectiveness of the technologies; and establish optimum operation protocols for full-scale systems.

Ultimately, granular ferric hydroxide proved to be the most effective for long-term arsenic removal. Conventional activated alumina required frequent regeneration, and high porosity activated alumina could not be used as a disposable media due to its short run time (one month). Iron modified activated alumina lasted 70 days before it had to be replaced and the replacement process was labor-intensive. The poorer results from the activated alumina media may be attributable to the high silica concentration and higher pH (7.2-7.5) of Tucson's raw water.

Granular ferric hydroxide kept arsenic levels below 0.010 mg/L even after 236 days of operation. However, its costs are approximately three times higher than costs for activated alumina treatment. Currently, granular ferric hydroxide supplies must be shipped wet, significantly increasing costs.

Ion Exchange Technology
Tucson Water pilot-tested indefinite brine recycling (IBR), an ion exchange treatment process. A single column was installed, and the unit was manually operated. The high sulfate levels in the raw water limited the effectiveness of IBR.

Micro-Sand-Based Technology
Through funding from the Arsenic Research Partnership (comprised of AWWARF, EPA, and the Association of California Water Authorities), Tucson Water pilot-tested micro-sand-assisted oxidation adsorption (MAOA). MAOA consistently removed arsenic from the raw water, though the treatment process caused high turbidity measurements in the treated water (as high as 8 NTU). (Higher turbidity levels are often associated with higher levels of disease-causing microorganisms.) MAOA is an option for Tucson if the technology can be refined in order to prevent these turbidity problems.

Conclusions

Both activated alumina and granular ferric hydroxide appear to be the best treatment options for Tucson water. The final report has not been completed and the City has not made any decisions as to their future approach to arsenic treatment

Preliminary cost estimates completed for the City indicate that each 1 MGD, will cost $1 million in capital costs and $200,000 to $250,000 in annual operation and maintenance costs. These costs assume that the media will be disposed of in a landfill as non-hazardous wastes.