Development of an Anionic Exchange Glass Fiber Substrate POU Device to Remove Arsenic

Xuan Li[a], Jinwen Wang[a], James Economy[a], Walton R. Kelly[b]

[a]Department of Materials Science, University of Illinois at Urbana-Champaign

[b]Illinois State Water Survey

Arsenic poisoning is one of the most widespread water-related problems in the world, causing bladder, lung, and skin cancer. Most notably, many millions of people in Bangladesh and eastern India have been exposed to elevated levels of arsenic in their drinking water in recent decades, resulting in a serious public health crisis. Due to increasing evidence of the negative health effects due to elevated arsenic levels in drinking water, the U.S. Environmental Protection Agency (USEPA) recently lowered the maximum contaminant level (MCL) to 10 micrograms per liter (µg/L). Those most at risk to arsenic poisoning are domestic well owners, whose water quality is not monitored or regulated. In the Midwestern United States, numerous wells contain arsenic concentrations higher than 10 µg/L. The development of improved or new treatment technologies for removal of the two major arsenic ions, arsenate [As(V)] and arsenite [As(III)], is needed to treat arsenic-contaminated water and protect public health.

In this project, an iron oxide (Fe_2O_3) coating on glass fiber (IOCGF) substrate system developed at the Department of Materials Science at the University of Illinois at Urbana-Champaign was evaluated for removal of arsenic from water. Results from laboratory batch and column tests indicated that the system effectively removed both As(V) and As(III) from deionized (DI) water and natural groundwater spiked with arsenic. The initial arsenic concentrations in the column tests were 300 µg/L and final concentrations < 3 µg/L. In the DI tests, the IOCGF effectively removed As(V) for 5000 bed volumes and As(III) for 2000 bed volumes, significantly greater than for other iron oxide systems tested by other researchers. The IOCGF was less effective when natural groundwater was used, although effluent arsenic concentrations remained below 10 µg/L for between 300 and 400 bed volumes. The decreased effectiveness was concluded to be due to interference by other ions, primarily bicarbonate.

A prototype of a point-of-use (POU) device was developed and tested in the homes of five volunteers in central Illinois who had elevated arsenic concentrations in their well water. Activated carbon filters in off-the-shelf water pitchers were removed and replaced with IOCGF. The top section of the pitcher was filled with approximately one liter of water which then percolated through the IOCGF into the bottom storage section of the pitcher. The volunteers were instructed to fill the pitcher once a day and collect samples from the tap and the pitcher once a week. Unfortunately, the POU devices did not perform adequately. They removed some arsenic from the water, but not enough for levels to fall below the MCL of 10 µg/L. All the sites had much higher bicarbonate concentrations compared to the groundwater used in the laboratory studies, and it seems likely bicarbonate reacted with the IOCGF and suppressed the arsenic removal. It is also possible that the POU design did not allow sufficient contact time with the water to efficiently remove arsenic.

Further research is being conducted at the Department of Materials Science, and a new filter system has been developed. This system depends on a chelating fiber that removes arsenic but is less vulnerable to competing ions and other contaminants than is IOCGF. Early laboratory results are promising, but further testing using natural groundwater needs to be done. Because of the simplicity and low cost of these systems, they still remain promising technologies for the removal of arsenic from drinking water.