A Green Approach to POU

By Chubb Michaud

Filtration systems remove arsenic from school's drinking water

For our protection, the U.S. Environmental Protection Agency (EPA) has established enforceable guidelines by which municipalities must abide and well owners should abide. These guidelines are known as maximum contaminant levels (MCLs).

Although these limits are intended to protect against waterborne contaminants, they do not always require 100% removal of these contaminants. MCLs should be interpreted as "safe for most," but just because your particular water source meets the MCLs, that does not guarantee "safe for all." In addition, water reports from municipal suppliers are time-weighted averages—they do not mean 100% compliance 100% of the time.

The numbers listed under the maximum contaminant level goals (MCLG) are the numbers considered "safe for all." Often, they are zero.

In 2002, EPA reduced the MCL for arsenic from 50 ppb to 10 ppb (now coincident with the recommendations of the World Health Organization [WHO]), because it determined that 50 ppb was not sufficiently protective.[1]

Reducing the level to 10 ppb may not protect everyone, however. Studies have found that prolonged consumption of 10 ppb arsenic in drinking water by pregnant and nursing mothers can have dire consequences on the health of their offspring, and it can increase the risk of cancer in the general public.[2] The MCLG, therefore, is zero.

In addition, EPA does not differentiate between various species of arsenic—it only specifies "total arsenic." Inorganic arsenic (salts) is, on average, 500 times more toxic than organic arsenic. As^{+3} is 60 times more toxic than As^{+5} and is more difficult to remove, yet the limit is the same.[3]

Nor does EPA specify the specie of chromium in water. Hexavalent chromium (Cr^{+6}) is 1,000 times more toxic than trivalent chromium (Cr^{+3}), which is sold as a nutritional supplement without a prescription.[4] The MCL for total chromium is 0.1 ppm. Hexavalent chromium, however, is considered toxic at fractional parts-per-billion levels.[5] Again, the only safe level of this contaminant is zero.

Taking Responsibility

The onus for trace-level contaminant detection and remediation does not fall on the municipality that supplies your water. It is only responsible for compliance with the MCL when the water leaves its plant. EPA compliance does not mean 100% safe 100% of the time—that is a near impossibility.

The responsibility lies with homeowners to protect themselves and their families. Point-of-use (POU) treatment is a top consideration for homeowners or renters who want protection against trace contaminants.

Only about 1% of the water supplied to a home is used for drinking and cooking. As the final barrier of protection, POU treatment need not be large, complicated or expensive. An in-line or under-sink filter system will do the trick.

POU Alternatives

Reverse osmosis (RO) is a time-proven technology that will reduce most trace elements to close to the MCLG.[6] A typical home RO drinking water system will reject 8 to 10 gal of feedwater (or more) for every gallon it produces due to the decreased flux rate as back pressure builds. If you consume 2 to 3 gal per day (gpd) of RO water, you may be sending more than 10,000 gal of municipal water down the drain every year.

Cartridge filters are another alternative. These can contain adsorbents and/or ion exchangers that can selectively remove arsenic, fluorides, chromium and other heavy metals. They are compact and 100% flow through, so they produce no waste and do not need a drain connection. The drawbacks are that they cannot be run at a high dispensing rate (see Figure 1) and there generally is no external indicator for capacity or "end of life."

Flow Limitations

Ion exchangers, activated carbon and other adsorbents (such as fluoride and arsenic media) produce their best results when designed and run at 1 to 2 gal per min (gpm) per cu ft. Figure 1 shows the typical cartridge flow rate to achieve 3.75 minutes empty bed contact time (EBCT), equivalent to 2 gpm per cu ft of media. That is the equivalent of about 100 to 200 cu cm per minute for a 2.5-by-10-in. cartridge. At that flow, it can take up to 37 minutes to produce a gallon of water. What if you want to fill your water bottle or cooking pot at 1 to 2 gpm? How do you build a cartridge filter that will run slowly and dispense quickly and then tell you when the filters need to be changed?

A Green Solution

The solution is simple: Produce water when you do not need it and store it, then dispense it as fast as you want at full line pressure.

The following design was produced by Systematix Co. and adopted by the Lincoln School in Yuba City, Calif., for the removal of arsenic reported at less than 20 ppb (see Figure 2).

Several cartridge filters had been

Figure 1. Flow Limitations for Cartridge Filters

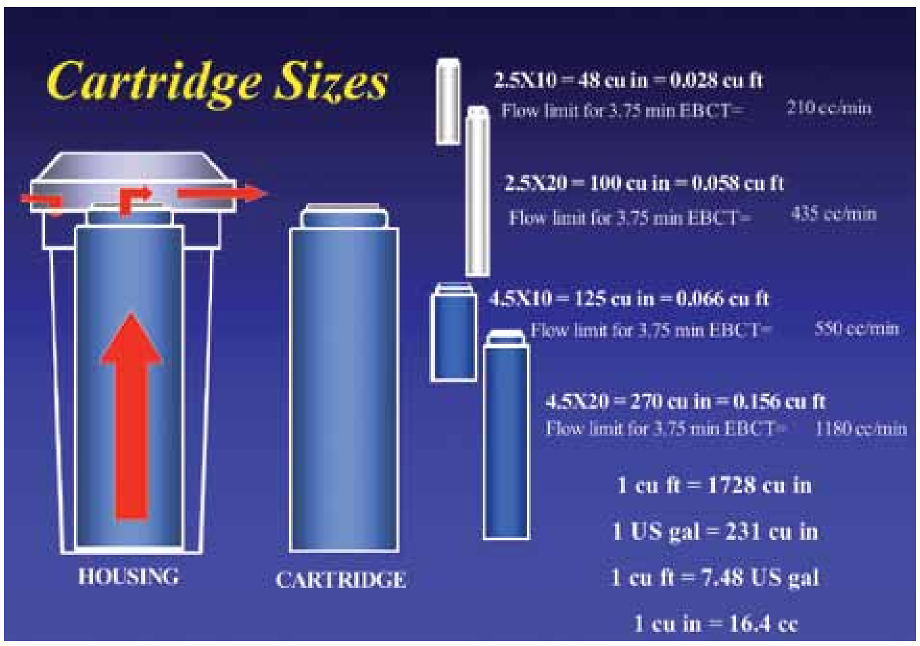
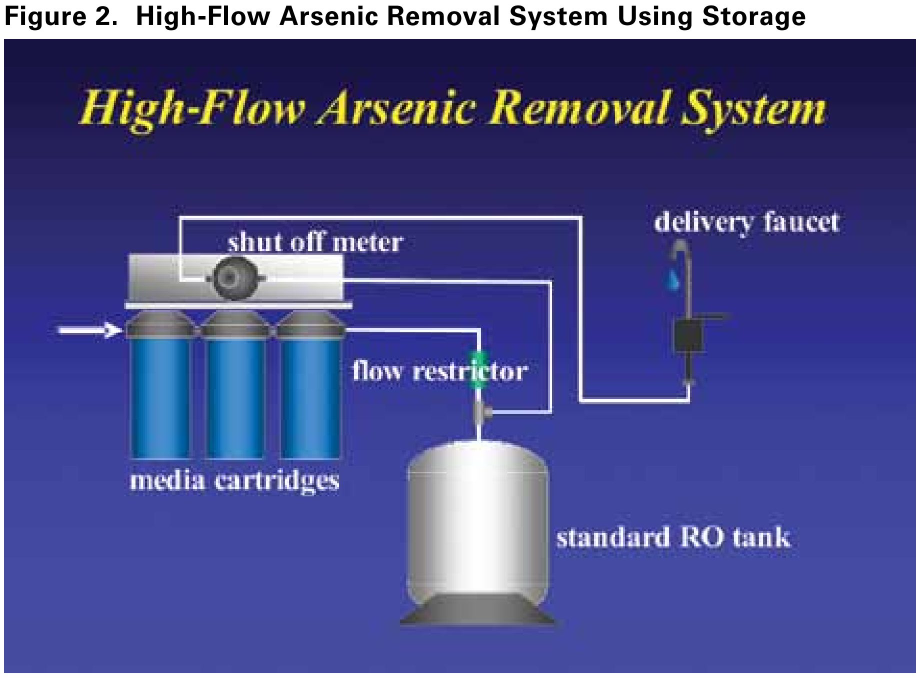


Figure 2. High-Flow Arsenic Removal System Using Storage



evaluated previously but none had shown reliable capacity due to the high relative flows. These new trial filters consisted of two in-series arsenic removal cartridges using a proprietary media followed by a granular carbon polisher for taste and freshness.

The feedwater came from the cold water line wall outlet located in each classroom, as well as throughout the playground. The effluent passed through a 250-cu-cm-per-minute flow restrictor, so product flow could completely fill the 4-gal pneumatic RO tank between class periods. When the faucet is opened, filtered water flows from the pressurized tank at about 1 gpm through a shutoff meter set for 1,500 gal. The 1,500-gal capacity was chosen as representing approximately 60,000 gal of throughput for a 1-cu-ft lead/lag adsorption system (about 50% of calculated capacity).

The pilot system was tested by the California Department of Health Services (DHS) to confirm that, at 1,500 gal, the effluent arsenic was non-detectable after the lead cartridge and the meter had shut the system off. Samples were taken and tested by an independent lab with oversight by DHS. When the results confirmed non-detectable levels, a total of 30 such systems were installed at the school.

According to Doug Reeder, the school principal, who monitors the usage and performance of the filters, when a unit shuts down (at 1,500 gal), the school take samples for testing. Once it confirms that the readings for the effluent are non-detectable, the meters are reset to an additional 1,500 gal. So far, none of the systems have broken through on arsenic removal and some have logged more than 4,000 gal of product run (equivalent to about 150,000 gal per cu ft).

Conclusions

Cartridge systems can provide reliable POU filters for the reduction of harmful contaminants such as arsenic, fluoride and heavy metals such as lead and hexavalent chromium. Care, however, must be taken in the design to ensure that flow rates through the cartridges are not excessive. High flow rates of 0.5 to 1 gpm through a 10-in. cartridge are equivalent to 20 to 40 gpm per cu ft. The EBCT is reduced to 12.5 seconds.

The design adopted by the Lincoln School has proven effective and long lasting, and does not waste water or require a drain connection. Cartridge filters can incorporate just about any media, including mixed bed deionization units for RO polishing for laboratory users. *wqp*

References

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