Evaluation of POU Devices for PFC Removal from Drinking Water

The 2007 legislature directed the Minnesota Department of Health (MDH) to evaluate point-of-use (POU) water-treatment devices for removing PFCs from drinking water. Through a competitive bid process, the MDH retained Water Science & Marketing, LLC (WSM) and the Water Quality Association (WQA) to perform this task. The WQA is one of three national, independent testing laboratories that evaluate and certify water treatment devices and chemicals. Throughout the study, all PFC laboratory analyses were performed by the MDH Public Health Laboratory.

The study consisted of three major tasks:

- Ask companies that make POU water treatment devices to suggest which of their devices may be effective in removing PFCs.
- Conduct laboratory testing (Phase I) of selected devices at the WQA testing facility in Lisle, Illinois, to assess performance of each device.
- Conduct field testing (Phase II) of devices that performed well in Phase I, utilizing water from one municipal well that contains multiple PFCs and one municipal well that contains only PFBA.

What is Point-of-Use (POU) Water Treatment?

A POU water-treatment device is installed at an individual tap, faucet, or outlet and reduces one or more contaminants at that one outlet. POU treatment can reduce exposure by treating water used for cooking and drinking. POU water-treatment devices utilize one or more different treatment methods, such as activated carbon (AC) adsorption, reverse osmosis (RO), or ion exchange. POU water-treatment devices include pitcher filters, faucet-mounted filters, or on- or under-the-counter units installed in the plumbing. Many POU devices include multiple treatment technologies. For example, a typical reverse-osmosis device will usually have a carbon prefilter and a carbon postfilter ("polishing filter").

Description of the Study

WSM contacted over 450 companies which manufacture/distribute water-treatment devices, requesting suggestions of candidate devices for testing. The devices had to be rated to treat at least 500 gallons of water, be available to the public, and meet relevant industry standards and certified by one or more of the following organizations:

- Canadian Standards Association (CSA)
- International Association of Plumbing and Mechanical Officials (IAPMO)
- NSF International (NSF)
- Underwriters Laboratory (UL)
- Water Quality Association (WQA)

A panel consisting of staff from MDH, WQA, WSM, and the U.S. Environmental Protection Agency selected 14 devices from those recommended by the manufacturers for testing, eight RO and six AC devices.

Laboratory Screening (Phase I)

The devices were first tested in a laboratory using three test solutions with different combinations of PFCs in water, all with PFC concentrations higher than have been generally found in the southeast metro area. AC devices were tested through 150 percent capacity. RO units were tested with rest cycles that simulate normal household use. AC prefilters were removed from the RO devices in order to better evaluate only the membrane performance. The treated waters were tested from after the membrane and after the postfilter(s) for RO devices.

Four RO devices did not show any PFC passage through the membrane in the Phase I laboratory tests and proceeded to Phase II field testing. One AC filter did not show any PFC breakthough. The membrane of a fifth RO device allowed some PFBA passage, but is equipped with the same carbon filter found to be effective alone at removing PFCs. The devices that proceeded directly to field testing were:

AC Devices: Culligan RC-EZ-4

RO Devices: 3M/CUNO/Water Factory (SQC-3)
EcoWater ERO-375E-CP
Kinetico Plus Deluxe VX
Pentair RO 3500-EX w/GS
Culligan Aqua Cleer

Additional Laboratory Testing (Phase I-B)

Additional laboratory tests (Phase I-B) were performed on two of the remaining RO devices to determine if the devices would be effective at treating 500 gallons of water. Although one or more PFCs passed through the RO membrane at trace levels in laboratory testing, the postfilter removed them. Three additional carbon devices were also further evaluated under conditions more typical of normal use. The test water with three PFCs was the same as used in Phase I. The five devices tested in Phase I-B were:

AC Devices: Aquion Rainsoft (Hydrefiner P-12 9878)
Kinetico MACguard 7500
Sears Kenmore (Elite 625.385010)

RO Devices: GE Smartwater (GXRM10GBL)
Watts (Premier WP-4V)

The Aquion Rainsoft did not show any breakthrough of PFCs before 500 gallons. The Sears Kenmore began to show PFBA breakthrough at 500 gallons, in the range of 0.2-0.7 micrograms per liter (µg/L). The Kinetico MACguard began to show PFBA breakthrough at 250 gallons, with concentrations in the range 1.4-2.2 µg/L at 500 gallons. For comparison, the Health-Based Value for PFBA is 7 µg/L. All five devices removed PFOA and PFOS. The two RO devices produced water with no detectable PFCs.

Field Testing (Phase II)

The six devices that passed the Phase I testing and the five devices tested in Phase I-B were all tested in the field during March-April 2008. Field testing of the eleven devices (four AC and seven RO) used water directly from two municipal wells in southern Washington County, one well in Oakdale with multiple PFCs and one well in St. Paul Park with only PFBA present. The eleven devices that were tested in the field were:

AC Devices: Aquion Rainsoft Hydrefiner (P-12 9878)
Culligan RC-EZ-4
Kinetico MACguard 7500
Sears Kenmore (Elite 625.385010)

RO Devices:* Culligan Aqua Cleer
3M/CUNO/Water Factory SQC-3 (04-045)
EcoWater ERO-375E-CP
GE Smartwater (GXRM10GBL)
Kinetico Plus Deluxe VX
Pentair RO 3500-EX w/GS**
Watts (Premier WP-4V)

*All RO devices are equipped with a preAC filter (before the RO membrane) and a post AC (after the RO membrane) polishing filter.

**The Pentair RO 3500-EX w/GS is also equipped with a resin filter in addition to an AC postfilter.

During field testing, all four AC devices removed PFCs to below analytical reporting level of 0.2 µg/L. The Aquion Rainsoft Hydrefiner did show some detection (but below the reporting level) of PFBA at initial startup for the first four minutes at the St. Paul Park site, but none subsequently. This pattern is consistent with air being entrained when the system is first used, reducing the normal flow through the AC filter. At only the Oakdale site, the Kinetico MACguard had detection of PFBA, below the reporting level, when it reached 100 percent capacity. The Culligan RC-EZ-4 and the Sears Kenmore Elite showed no PFCs above the detection limit of 0.05 µg/L.

All seven RO devices removed PFCs to levels below the detection limit. Although the Pentair RO 3500-EX w/GS is equipped with an additional resin filter, it appears that this device would be as effective without this additional filter. In fact, this resin filter was never really challenged with PFCs because of the preceding AC and RO treatment.

Conclusions

All four AC devices and all seven RO devices tested in laboratory testing and field testing were effective in removing PFCs in water. Two AC devices, the Kinetico MACguard 7500 and the Sears Kenmore (Elite 625.385010) did show breakthrough of PFBA in laboratory testing before reaching 500 gallons of water treated, but the PFBA concentration remain below the HBV of 7 µg/L. All RO devices removed PFCs to below reporting limits of 0.2 µg/L. The effectiveness of RO devices is due, in part, to these devices having both AC and RO components.

Flow Rates of Water Treatment for Tested POU Water Treatment Devices

Residential water treatment devices usually produce water at lower flow rates than is typically delivered by a faucet and a kitchen sink. AC filters and RO devices treat water through very different processes. In an AC device, water simply flows through the filter and streams out the other end. The AC filters listed above had initial flow rates in the range of 0.2–0.9 gallons per minute. Flow rates may gradually decline over time with use. Even for the same device, flow rates can vary, depending on the general water quality of the source water (hardness, iron/manganese, organic material, suspended particles); water-system pressure; and plumbing design.

The membrane component of RO devices purifies water by forcing part of the incoming water through a semipermeable membrane, allowing "clean" water to pass through and leaving many chemicals in the water behind as a more concentrated solution. This concentrate or wastewater is discharged to the drain. The treated water is typically stored in a small pressure tank for later use. Tank size is typically 1.5–3.0 gallons, although manufacturers often have several sizes available. For the RO devices above, the amount of treated water produced ranged over 10.5–40 gallons per day.

As described above, RO devices generate wastewater on the upstream side of the membrane. This water is discharged to the home wastewater drain. The amount of wastewater produced per gallon of treated water varies. For the devices tested, the amount of wastewater ranged from 1.5 to 4.7 gallons per gallon of treated water produced.

Important Points to Consider

As with any appliance, it is important to follow the manufacturer or dealer recommendations regarding installation, operation, maintenance, and replacement of components of the POU water-treatment device. In particular, AC filters, RO membranes, and other filter elements have a limited service life and must be periodically replaced. Manufacturer recommendations vary, but many suggest replacing filters after 500 gallons of treatment or every six months. Most manufacturers incorporate some type of sensor, monitor, or automatic shutoff to notify the user when the membrane needs replacement.

All RO devices in this study are also equipped with AC pre and postfilters. This design is typical in the industry. The prefilter is primarily designed to remove some chemicals, such as chlorine, that may damage the RO membrane. The postfilter, often referred to as the "polishing filter," is designed to remove any chemicals that pass through the membrane, including chemicals that impart some taste/odor, but it also provides additional removal capacity of PFCs. AC devices and

the AC filters on RO devices also have the ability to remove some other chemicals in the water, especially organic compounds and chlorine. However, AC devices do not remove most inorganic chemicals, such as hardness or iron. RO devices can remove many inorganic chemicals, notably nitrate, which is also found in some groundwater in southern Washington County.

The type of filter that works best for you should be based on your average daily water use, available space, and plumbing access. If you have a water treatment device installed, you should hire a plumber or water conditioning contractor, licensed by the Minnesota Department of Labor and Industry.

Additional Information

The full report, *Performance Evaluation – Removal of Perfluorchemicals with Point-of-Use (POU) Water Treatment Devices*, published by Water Science & Marketing, LLC, can be found at: www.health.state.mn.us/divs/eh/wells/waterquality/poudevicefinal.pdf

For more information about Evaluation of POU Water Treatment Devices for PFC Removal Final Report, contact the
Well Management Section at 651/201-4600 or 800/383-9808
www.health.state.mn.us/divs/eh/wells

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