Environmental Quality Program
Environmental Services Division
Department of Health & Human Services
Municipality of Anchorage

Final Report on the Performance of Two Point-of-Use Drinking Water Arsenic Treatment Systems

The Environmental Services Division of the Municipal Department of Health and Human Services (DHHS) has evaluated the performance of two point-of-use treatment systems designed to remove arsenic from drinking water. Point-of-use systems treat water at a single location, normally water that will be used for cooking and drinking. Typically these systems are installed as an auxiliary tap at the kitchen sink. Water used for bathing, laundry, lawn irrigation, etc. are not treated. DHHS paid for the initial installation of these two point-of-use systems, and monitored their performance monthly for two years.

These systems were installed at the kitchen taps of two homes in the Sand Lake area in west Anchorage. Drinking water for both of these homes is provided by private wells, identified from previous sampling as having elevated arsenic levels. Arsenic concentrations in many wells in the Sand Lake area have been found to be substantially above the newly established U. S. Environmental Protection Agency's (EPA) drinking water maximum contaminant level (MCL) for public water systems.[1] A discussion of the performance of these two systems during the two years of evaluation follows.

Apyron Targeted Chemical Media System

This system was installed in April 2001 in a home on Sundi Drive. This point-of-use drinking water treatment system uses targeted chemical media to remove arsenic. It was installed at the kitchen sink as an auxiliary tap. The basic filter design incorporates a housing mounted permanently below the sink and a removable cartridge containing the filtration media. Although untreated water remains available at the kitchen tap, the family living in the home has used the treatment system to provide water for drinking and cooking water since installation. The initial cost of the filter unit, including installation was $448.

Sampling was conducted monthly starting in December 2001. The performance of the Apyron system is shown in Figure 1. The arsenic level in untreated water from the kitchen tap varied between 69.2 and 94.0 parts per billion (PPB) during the two years of monitoring. Arsenic concentrations in the treated water varied from undetected to a maximum of 37.0 PPB, above the 10 PPB MCL for public water systems. During the effective life of the filter cartridge post-treatment concentration remained below the EPA MCL. Post-treatment arsenic concentrations above the EPA MCL indicated that the filter cartridge had worn out and replacement was necessary. The average arsenic removal efficiency over the entire two year period was 91.9%

A few months into the study a slight rise in post-treatment arsenic concentration occurred (Figure 1.) This rise is reflective of the period of time between installation and the commencement of sampling. While conclusive data is absent, it can be inferred that this filter lasted approximately 10 months. This rise does not reflect that the filter lasted only two months before replacement was necessary. In March 2002, the original filter cartridge was replaced with a redesigned filter cartridge, which according to the manufacturer, has a longer effective

[1] The EPA established a new arsenic drinking water MCL of 10 PPB .for public water systems in October 2001. All public water systems are required to meet the standard by 2006. This standard does not apply to private wells, however it can be used as a relative gauge of water quality.

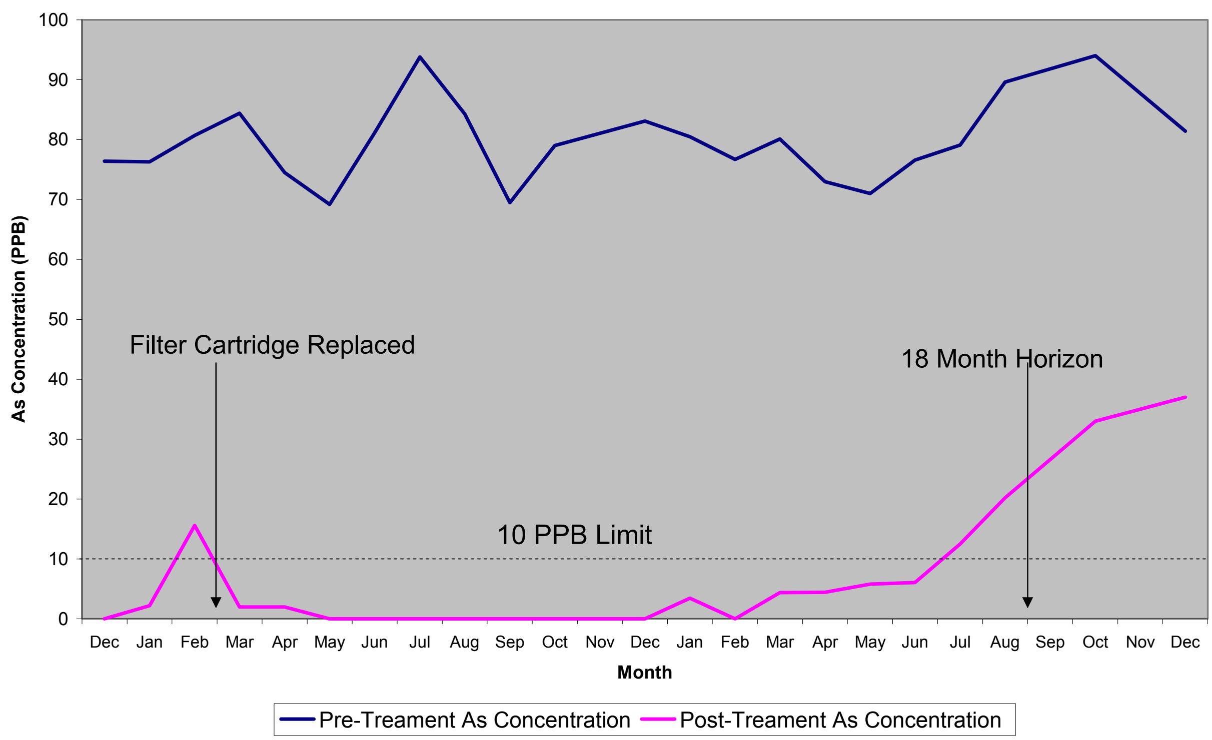
lifetime than the old filter unit. The vendor claimed that the redesigned filter cartridge would provide at least 18 months of effective arsenic removal.

Following filter cartridge replacement, the post-treatment arsenic concentration fell to 2.0 PPB. During the 18-month manufacturer's recommended filter lifetime arsenic removal averaged 95.6%. However, during the last two months of the 18-month purported effective life, the post treatment arsenic concentration climbed above the MCL of 10 PPB.

The filter cartridge remained in use beyond the 18-month recommended life. After 22 months of operation, removal rates were just over 50% and post-treatment arsenic concentrations had climbed to 37.0 PPB.

Figure 1.

Apyron Filter Pre and Post-Treatment Arsenic Concentrations



<u>Vertex Water Machine Reverse Osmosis System</u>

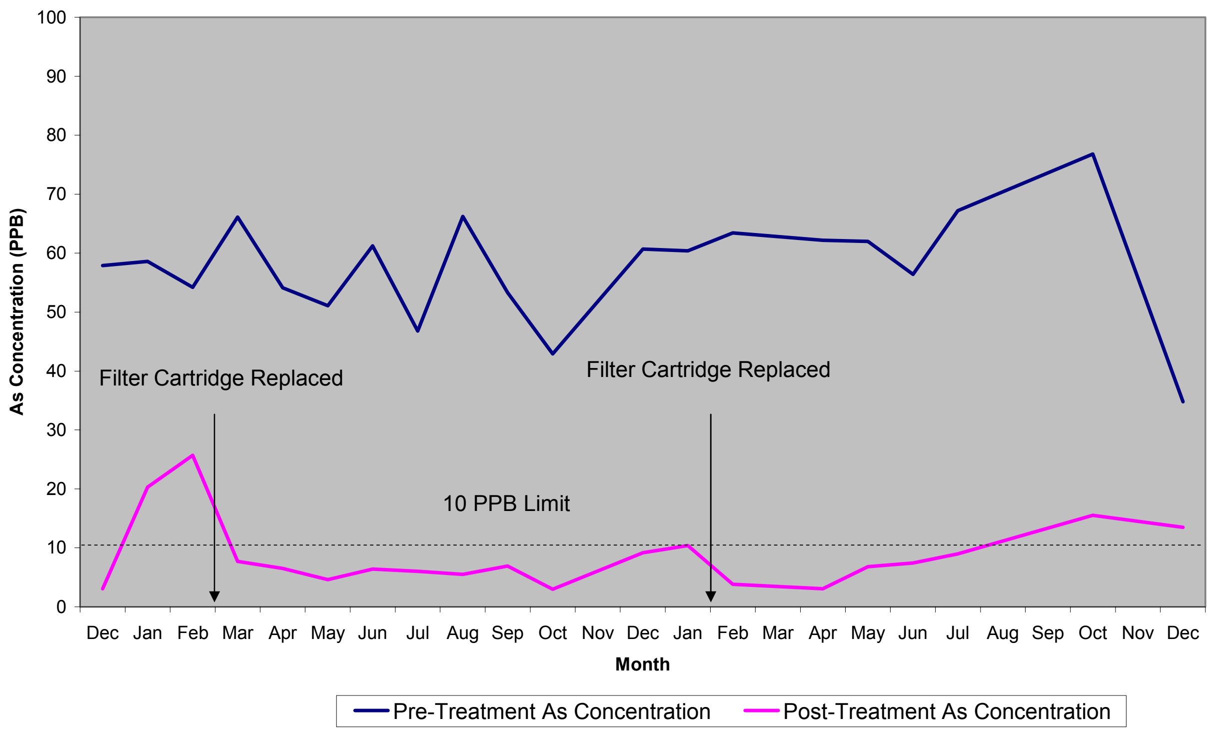
This system was installed in a home on Endicott Street in late-November 2001. Like the Apyron system discussed above, the Vertex system is also point-of-use and was installed at the kitchen sink and for treatment of water used for drinking and cooking only. The system also utilizes a permanent housing mounted below the sink and replaceable filter cartridges. This system utilizes reverse osmosis to remove arsenic. The initial cost of this unit, including installation, was $294.

The arsenic level in the untreated well water varied between 76.8 and 34.8 PPB during the two years that sampling was conducted. Arsenic levels in the untreated water from this well were less than those measured at the Sundi Drive test site. Arsenic concentrations in treated water varied from 3.0 PPB to 25.7 PPB. The average arsenic removal efficiency over the two years of study was 86.8%.

Monthly performance of the Vertex system is shown in Figure 2. Samples were collected monthly starting in December 2001. As was the case with the Apyron filter media system, elevated post-treatment arsenic concentrations indicated that a filter change was necessary. During the sampling period filters for this system were changed twice. The first replacement occurred following the February 2002 sampling which measured a post-treatment arsenic concentration above the EPA MCL. During the following 10 months, the post-treatment arsenic concentration remained below the EPA MCL (Figure 2.). A noticeable rise in the post- treatment arsenic concentration occurred in the 10^{th} month of filter use and by the 11^{th} month the post-treatment concentration was above the EPA MCL. The second filter changed occurred after this elevated sample in January 2003. Following the installation of the second filter, the post-treatment arsenic concentration remained below the EPA MCL for a shorter period of time. Within six months, in July 2003, post-treatment arsenic was 9.0 PPB, approaching the EPA MCL. The next time a sample was collected, in October, nine months after filter replacement, the arsenic level in the treated water was 15.5 PPB (Figure 2.)

Figure 2.

Vertex Filter Pre and Post-Treatment Arsenic Concentration



Conclusions

During the study period both systems proved capable of removing arsenic and providing drinking water with arsenic levels below the EPA recommended MCL of 10 PPB. In general, the Apyron targeted media system provided more effective removal of arsenic than the Vertex reverse osmosis system. During two years of sampling, the Apyron system had an average arsenic removal efficiency of 91.9% while the Vertex system had an average removal efficiency of 84.4%. The average concentration of arsenic in water treated with the Apyron system was 6.8 PPB. For the Vertex system the post-treatment concentration was 7.4 PPB.

A large difference was observed in the effective life spans of the filters used in the two systems. The Apyron replacement filter provided treated water below the 10 PPB MCL for a period of 16 months. The Vertex filter had a shorter effective lifespan. Post-treatment arsenic concentrations for the Vertex system climbed above the MCL 11 months after the installation of the first filter and less than 9 months after the installation of the second.

Estimated annual costs a potential user would expect to occur through replacement of filters are shown in Table 1. Annual cost of replacement filters assuming annual replacement for the Apyron system and semi-annual replacement for the Vertex system. Replacement of filters for both units is relatively simple; filter cartridges screw into an orifice on the system. No additional costs would be expected for changing of filters or other maintenance. It should be noted that the Apyron filter is significantly more expensive to purchase and install than the Vertex Water Machine.

Table 1.

Cost of use point of use arsenic removal treatment systems.

Filter	Purchase and Installation Cost	Replacement Filter Cost	Recommended Replacement Interval of Filter	Estimated Monthly Cost of Use	Estimated Annual Cost of Use
Apryon Targeted Media	$448.00	$120.00	1 Year[2]	$10.00	$120.00
Vertex Pure Water Machine	$294.00	$70.00	6 Months[3]	$11.67	$140.04

The lifetime of filter cartridges is likely to be affected by the quantity and chemistry of the water being treated. To ensure that post-treatment arsenic concentrations remain below 10 PPB, any point of use system should be tested periodically after installation to determine appropriate filter life for the system in that home. The performance of Vertex water machine suggests that the filter life of cartridges can vary. Therefore it would be wise to observe the performance of more than one than one filter before determining filter life and the interval filters should be changed to continuously provide water of acceptable quality. Subsequent testing on annual basis would help ensure that all components of the filter are functioning properly.

<u>Limitations/Need for Future Study</u>

Although this study indicated that the Vertex reverse osmosis system could effectively remove arsenic and produce water below the 10 PPB MCL, ongoing research at the University of Alaska Anchorage on similar point of use reverse osmosis systems suggests that they may be limited in their ability to effectively remove arsenic. This research suggests that reverse osmosis systems are significantly less effective at removing arsenic from water with high ratios of the un-oxidized species of arsenic, arsenic^{+3}. Further research is necessary to determine limitations of reverse osmosis as a point of use treatment option in Anchorage

As discussed above, performance of any filter system could be dramatically affected by water chemistry. Alkalinity, the presence of suspended solids and/or other dissolved ions could affect

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[2] The Apyron filter produced water with an arsenic concentration below the MCL for 16 months. Based on this result, a nominal filter life span of 12 months was assumed for this cost computation.

[3] The first Vertex filter produced water meeting the MCL for arsenic for 11 months, the second for less than 9 months. A nominal filter life span of 6 months was assumed for this cost computation.

the performance of various systems in different ways. The development of appropriate selection guidelines based on water chemistry would be useful when trying to choose a particular treatment system for a water source. Further work is needed to determine factors that would diminish or enhance the ability of targeted media, reverse osmosis or other treatment method to remove arsenic from drinking water.

APPENDIX A:
Summary of Monthly Testing

Test Date	Sundi Untreated (PPB)	Sundi Treated (PPB)	Arsenic Removed (PPB)	% Removal (%)	Endicott Untreated (PPB)	Endicott Treated (PPB)	Arsenic Removed (PPB)	% Removal (%)
Dec 2001	76.4	0.0	76.4	100.0	57.9	3.06	54.8	94.7
Jan 2002	76.3	2.2	74.1	97.1	58.6	20.3	38.3	65.4
Feb 2002	80.7	15.6	65.1	80.7	54.2	25.7	28.5	52.6
Mar 2002	84.4	2.0	82.4	97.6	66.1	7.7	58.4	88.4
Apr 2002	74.5	2.0	72.5	97.3	54.1	6.5	47.6	88.0
May 2002	69.2	0.0	69.2	100.0	51.1	4.6	46.5	91.0
Jun 2002	81.2	0.0	81.2	100.0	61.2	6.4	54.8	89.5
Jul 2002	93.8	0.0	93.8	100.0	46.8	6.0	40.8	87.2
Aug 2002	84.3	0.0	84.3	100.0	66.2	5.5	60.7	91.7
Sep 2002	69.5	0.0	69.5	100.0	53.3	6.9	46.4	87.0
Oct 2002	79	0.0	79.0	100.0	42.9	3.0	39.9	93.0
Nov 2002	NT	NT	NT	NT	NT	NT	NT	NT
Dec 2002	83.1	0.0	83.1	100.0	60.7	9.2	51.5	84.9
Jan 2003	80.5	3.4	77.1	95.7	60.4	10.4	50.0	82.8
Feb 2003	76.7	0	76.7	100.0	63.4	3.83	59.6	94.0
Mar 2003	80.1	4.38	75.7	94.5	NT	NT	0.0	NT
Apr 2003	73.0	4.43	68.6	93.9	62.2	3.06	59.1	95.1
May 2003	71.0	5.80	65.2	91.8	62.0	6.80	55.2	89.0
Jun 2003	76.6	6.07	70.5	92.1	56.4	7.45	49.0	86.8
Jul 2003	79.1	12.5	66.6	84.2	67.2	8.96	58.2	86.7
Aug 2003	89.6	20.2	69.4	77.5	NT	NT	NT	NT
Sep 2003	NT	NT	NT	NT	NT	NT	NT	NT
Oct 2003	94	33	61.0	64.9	76.8	15.5	61.3	79.8
Nov 2003	NT	NT	NT	NT	NT	NT	NT	NT
Dec 2003	81.4	37	44.4	54.5	34.8	13.5	21.3	61.2
MAX	94.0	37.0	93.8	100.0	76.8	25.7	61.3	95.1
MIN	69.2	0.0	44.4	54.5	34.8	3.0	21.3	52.6
AVG	79.7	6.8	73.0	91.9	57.8	8.7	49.1	84.4