Treatment Chemicals Contribute to Arsenic Levels

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Arsenic is an issue that water utilities no longer can avoid. The US Environmental Protection Agency is expected to propose a reduction in the federal drinking water standard on arsenic from 50 µg/L to 5 µg/L later this year, although USEPA is also considering setting the maximum contaminant level at 3 µg/L, 10 µg/L, and 20 µg/L The final arsenic rule is due by Jan. 1, 2001.

Utilities should test their sources of water for arsenic and compare them with the proposed levels of 3, 5, and 10 µg/L. However, testing source water alone may not be sufficient to determine the arsenic load in finished water. Some treatment chemicals may also contain trace amounts of arsenic. Utilities should review and estimate the maximum possible arsenic concentrations contributed by the chemicals they use in drinking water treatment. Even trace amounts add up and may contribute a substantial portion—possibly up to 10 percent—of a 3 or 5 µg/L maximum contaminant level.

Connecticut Experience

The South Central Connecticut Regional Water Authority has three surface water treatment plants (SWTPs) and five wellfields. Recently, SCCRWA calculated the arsenic burden derived from chemicals routinely used to treat surface and groundwater at these facilities. Those chemicals are listed in Table 1.

To estimate the trace arsenic levels in the bulk treatment chemicals, data from the suppliers' analysis report or product specifications were used. The resulting trace arsenic concentrations in the finished water that were contributed by the treatment chemicals were computed by one of the following two methods:

1. For those chemicals with dosages expressed as mg/L of product chemicals (such as polymer, sulfuric acid, bimetallic zinc metaphosphate, and potassium permanganate), the resulting trace arsenic concentration in the finished water was computed by multiplying the chemical dosage by the trace arsenic level in the bulk treatment chemical.

2. For other chemicals (such as alum, ferric chloride, caustic soda, and fluorosilicic acid), a dilution factor was determined by dividing the chemical concentration by the chemical dosage. The resulting trace arsenic concentration in the finished water was computed by dividing the trace arsenic level in the bulk treatment chemical by the dilution factor.

Information produced by several calculations is tabulated as follows:

- Table 2 shows the maximum possible arsenic concentrations contributed by treatment chemicals for one surface water treatment plant that uses alum (0.279 µg/L arsenic contributed).
- Table 3 shows the maximum possible arsenic concentrations contributed by treatment chemicals for the wellfield, which uses sodium hypochlorite for disinfection (0.249 µg/L arsenic contributed).

Treatment Chemical	# Surface Water Treatment Plants (3 total)	# Groundwater Treatment Facilities (5 total)
Sodium hydroxide	3	Not used
Sulfuric acid	1	Not used
Alum	2	Not used
Potassium permanganate	2	Not used
Ferric chloride	1	Not used
Synthetic polymer A	1	Not used
Synthetic polymer B	1	Not used
Chlorine	3	4
Sodium hypochlorite	Not used	1
Bimetallic zinc metaphosphate	3	5
Fluorosilicic acid	3	5

Table 1. Chemicals routinely used by the South Central Connecticut Regional Water Authority, and the number of facilities where they are used.

- Table 4 shows the range of maximum arsenic contribution by treatment chemicals for the SCCRWA (range of all compounds, 0.0002-0.245 µg/L).
- Table 5 compares in finished water the calculated amount of arsenic that is contributed by treatment chemicals with the analytical result (overall calculated range, 0.248—0.306 µg/L; analytical result <1µg/L in all cases).

These data show that in finished water the theoretical arsenic concentrations attributable to normal dosages of water treatment chemicals are extremely low (Tables 2, 3, and 4). This conclusion is supported by the analytical data (Table 5), which show arsenic concentrations to be below 1.0 µg/L in all of the SCCRWA's surface and groundwater treatment facility finished waters.

Conclusion

If the standard were set at 3 µg/L, about 10 percent of the MCL would come from the treatment chemicals, hardly a minimal amount. It is also interesting to note that about 90 percent of the arsenic that would be contributed by treatment chemicals is attributable to fluoride addition.

If your processes include the addition of chemicals, ask your manufacturer for the amount of arsenic in each. If necessary, obtain conversion charts for diluted products, as well. Then calculate how much arsenic those chemicals will add to your finished water. If the total is close to the MCLs proposed by USEPA, you have reason for concern.

To find out more about the proposed arsenic rule, go to the agency's Web site, <www.epa.gov/safewater/arsenic.html>, or call the Safe Drinking Water Hotline at (800) 426-2791.

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Treatment Chemical	Amount of Arsenic in Product	Dosage	Calculation of Contribution	Arsenic Contribution
50% alum	0.25 mg/L	10 mg/L*	Chemical concentration of 50% alum = 650 mg/mL Dilution factor = 650 x 1,000 ÷10 = 65,000 Arsenic contribution = 0.25 ÷ 65,000 mg/L	0.00385 µg/L
Polymer A	< 0.5 mg/L	2.0 mg/L	Arsenic contribution = 0.5 mg/L x 2 mg/L	0.001µg/L
50% Sodium hydroxide (NaOH)	1.5 mg/L (maximum)	12.5 mg/L* (maximum)	Chemical concentration of 50% NaOH = 770 mg/mL Dilution factor = (770 x 1,000) ÷12.5 = 61,600 Arsenic contribution = 1.5 ÷ 61,600 mg/L	0.024 mg/L
Fluorosilicic acid (H_2SiF_6)	Maximum = 60 mg/L Normal = 28 mg/L	1.0 mg/L* as F	H_2SiF_6 solution contains 20% F or 244.8 mg/mL of F F dosage = 1.0 mg/L as F Dilution factor = 244.8 x 1,000 ÷1.0 = 244,800 Maximum arsenic contribution = 60 / 244,800 mg/L = 0.245 µg/L Normal arsenic contribution = 28 ÷ 244,800 mg/L=0.114 µg/L	0.114 µg/L (normal) 0.245 µg/L (maximum)
Bimetallic zinc metaphosphate	<2 mg/L	1.7 mg/L	Arsenic contribution = 2 mg/L x 1.7 mg/L	0.0034 µg/L
Potassium permanganate ($KMnO_4$)	4.8 mg/L	0.35 mg/L	Arsenic contribution = 4.8 mg/L x 0.35 mg/L	0.00168 µg/L
Chlorine	All manufacturer reports indicate that arsenic is not present in gaseous chlorine.			0
Total arsenic contributed by treatment chemicals				0.279 µg/L (maximum)

*Based on dry equivalents.

Table 2. Arsenic contributed by chemicals used to treat surface water at Lake Gaillard Water Treatment Plant

Table 3. Arsenic contributed by chemicals used to treat groundwater at North Cheshire Wellfield

Treatment Chemical	Amount of Arsenic in Product	Dosage	Calculation of Contribution	Arsenic Contribution
Sodium hypochlorite (NaOCl)	0.8 mg/L (maximum)	1.2 mg/L	1 lb of chlorine reacts with 1.128 lb of caustic soda to produce 1.05 lb of NaOCl. An excess of caustic soda is used as a stabilizer. Based on the arsenic concentration in the 50% caustic soda, the maximum arsenic concentration in the NaOCl is estimated to be 0.8 mg/L. Arsenic contribution = 0.8 mg/L x 1.2 mg/L	0.00096 µg/L
Fluorosilicic acid (H_2SiF_6)	60 mg/L (maximum)	1.0 mg/L as F	Dilution factor = 244.8 x 1,000 ÷1.0 = 244,800 Maximum arsenic contribution = 60 ÷ 244,800 mg/L	0.245 µg/L
Bimetallic zinc metaphosphate	< 2 mg/L	1.7 mg/L	Arsenic contribution = 2 mg/L x 1.7 mg/L	0.0034 µg/L
Total arsenic contributed by treatment chemicals				0.249 µg/L (maximum)

Treatment Chemical	Range of Chemical Dosage (mg/L)	Range of Maximum Arsenic Contribution (µg/L in finished water)
Sodium hydroxide	**8.0–12.5**	**0.0156–0.024**
Sulfuric acid	**20**	**0.0002**
Alum	**10–80**	**0.00385–0.0308**
Potassium permanganate	**0.30–0.35**	**0.0014–0.00168**
Ferric chloride	**7**	**0.037**
Synthetic polymer A	**2.0**	**0.001**
Synthetic polymer B	**4.0**	**0.004**
Chlorine	**1.2–2.8**	**0.000**
Sodium hypochlorite	**1.2**	**0.00096**
Bimetallic zinc metaphosphate	**1.5–1.7**	**0.0030–0.0034**
Fluorosilicic acid	**1.0**	**0.245**

Table 4. Maximum finished water arsenic concentrations based on chemical dosages applied in the treatment facilities

Treatment Facility	Trace Arsenic Concentration (µg/L) Calculated Maximum	Trace Arsenic Concentration (µg/L) Analytical Result
Lake Gaillard WTP*	**0.279**	**<1**
Lake Saltonstall WTP	**0.299**	**<1**
West River WTP	**0.306**	**<1**
North Cheshire Wellfield	**0.249**	**<1**
All other wellfields (N=4)	**0.248**	**<1**

*Water treatment plant

Table 5. Maximum finished water arsenic concentrations based on chemical dosages applied in the treatment facilities