

## SELENIUM

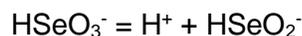
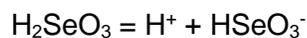
Contaminant	In Water As (pH = 7.0 to 9.5)	Maximum Contaminant Level
<b>Selenium (Se)</b>	selenate ( $\text{SeO}_4^{2-}$ ) biselenite ( $\text{HSeO}_3^-$ ) selenite ( $\text{SeO}_3^{2-}$ )	<b>US EPA:</b> MCL* = 0.05 mg/L MCLG** = 0.05 mg/L <b>WHO† Guideline</b> = 0.04 mg/L
<b>Sources of Contaminant</b>	Natural deposits Releases from copper smelting	
<b>Potential Health Effects</b>	Hair and fingernail changes Damage to the peripheral nervous system Fatigue and irritability	
<b>Treatment Methods</b> <b>Point-of-Entry (POE)</b> <b>Point-of-Use (POU)</b>	Activated alumina adsorption (85-95% reduction) Strong base anion type I $\text{Cl}^-$ exchange (60-95% reduction) Distillation (>98% reduction) Reverse osmosis (>90% reduction)	
<p>*Maximum Contaminant Level (MCL) — The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.</p> <p>**Maximum Contaminant Level Goal (MCLG) - The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.</p> <p>WHO† - World Health Organization</p>		

Selenium is a metal found in natural deposits as ores containing other elements. The greatest use of selenium compounds is in electronic and photocopier components, but they are widely used in other products as well. Selenium releases to the environment have been primarily from copper smelting industries. The largest releases from 1987 to 1993 occurred in Utah. The largest direct releases to water occurred also at that time period in Indiana.

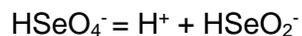
The main source of selenium intake for humans is through plant foods in which the plants concentrate the selenium found in soil or taken from groundwater used for irrigation. Selenium (Se) contamination of potable water supplies at concentrations above the current MCL of 0.05 milligram per liter (mg/L) is rare. In a 1982 study AWWA concluded that only 44 water supplies needed to treat for this contaminant.

At typical groundwater pH values (7.0 to 9.5) only anionic forms of selenious (Se IV) or selenic (Se VI) acid are found.

**Se (IV) Selenious Acid Dissociation Equilibria:**



**Se (VI) Selenic Acid Dissociation Equilibria:**



Under oxidizing conditions, Se (VI) will predominate at pH values less than 8.15 and the divalent selenate ( $\text{SeO}_4^{2-}$ ) anion will be found demonstrating chemical behavior similar to the sulfate ion. The predominant species under reducing conditions will be the Se (IV) species. At pH less than 8.15 the monovalent biselenite anion ( $\text{HSeO}_3^-$ ) will dominate and at pH values greater than 8.15, the divalent selenite ( $\text{SeO}_3^{2-}$ ) will form.

## HEALTH EFFECTS

In trace quantities, selenium appears to be essential for nutrition of human beings while larger concentrations produce definite toxic symptoms. Although retained in the liver and kidney in small amounts, selenium salts, for the most part, are excreted. Signs of selenium toxicity occur at selenium ingestion levels of 0.7 –7.0 mg/day while 200 µg/day (0.2 mg/day) is nutritionally adequate

The USEPA has set the Maximum Contaminant Level (MCL) and the Maximum Contaminant Level Goal (MCLG) in drinking water for selenium at 0.05 mg/L.

EPA has found selenium to potentially cause the following health effects when people are exposed to it at levels above the MCL for relatively short periods of time: hair and fingernail changes; damage to the peripheral nervous system; fatigue and irritability.

Long-term, selenium has the potential to cause the following effects from a lifetime exposure at levels above the MCL: hair and fingernail loss; damage to kidney and liver tissue, and problems with the nervous and circulatory systems.

## TREATMENT METHODS

<b>Residential</b>  <b>Point-of-Entry</b> <b>Point-of-Use</b>	Activated alumina adsorption (85-95% reduction) Strong base anion type I Cl <sup>-</sup> exchange (60-95% reduction) Distillation (>98% reduction) Reverse osmosis (>90% reduction)
<b>Municipal</b>	Activated alumina Coagulation/filtration Lime softening

Visit [WQA.org](http://WQA.org) or [NSF.org](http://NSF.org) to search for products certified to NSF/ANSI 58, NSF/ANSI 62, NSF/ANSI 53, WQA S-400, and WQA S-200 for selenium reduction claims.

Several techniques may be used to reduce the level of selenium from drinking water: anion exchange, activated alumina (AA), reverse osmosis (RO), and distillation.

Anion Exchange can reduce selenium by 90-95%, where the selenate ion is strongly preferred. Although Se (IV) is more difficult to oxidize than As (III) is to As (V), this can readily be accomplished with free chlorine. The optimal rate of oxidation is found to be between pH 6.5 and 8.0 where Se (IV) can be converted to Se (VI) within 5 minutes at a free chlorine concentration of 2 mg/L. At pH 9.0, only 15% of the Se (IV) has been found to be converted with 2 mg/L of free chlorine. Pure oxygen was found to be ineffective at oxidizing Se (IV) to Se (VI). The run lengths that can be achieved when using oxidation prior to a strong base anion exchange resin system in chloride form are approximately 275 bed volumes (BV's). While this may not be considered an outstanding capacity, it should be noted that anion exchange resin's high affinity for the selenate ion will prevent chromatographic dumping and runs could be safely terminated at sulfate breakthrough.

Other techniques used for selenium removal include distillation (> 98% reduction), reverse osmosis (RO) (> 90% reduction), and activated alumina (AA) (85-95% reduction). Several point-of-use (POU) RO and POU distillation products have been tested and certified by ANSI-accredited third party organizations for selenium reduction.

Between pH 5 - 6, AA is very effective in removing Se (IV). But when the predominant species is Se (VI), AA is poor due to competition from the sulfate ion. In general, AA can be used from pH 3.0 – 8.0 for biselenite, Se (IV), removal. The media in such systems can be removed and recycled using the standard acid-base regeneration procedure normally employed when AA is used for fluoride removal.

At the present time, it appears that any of these methods can be made practical, feasible, and economical for selenium reduction when considering point-of-entry (POE) or POU devices.

The treatment methods listed below are generally recognized as techniques which can effectively reduce listed contaminants sufficiently to meet or exceed the relevant MCL. Selection of a particular device or system for health contaminant reduction should be made only after a careful consideration of its performance capabilities based on results from competent equipment validation testing for the specific contaminant to be reduced.

As part of the POE installation procedure, system performance characteristics should be verified by tests conducted under established test procedures and water analyses. Thereafter, the resulting water should be monitored periodically to verify continued performance. The application of the water treatment equipment must be controlled diligently to ensure that acceptable feed water conditions and equipment capacity are not exceeded.

## **REGULATIONS**

In the United States the EPA, under the authority of the Safe Drinking Water Act (SDWA), has set the Maximum Contaminant Level Goal (MCLG) for selenium at 0.05 mg/L or ppm. This is the health-based goal at which no known or anticipated adverse effects on human health occur and for which an adequate margin of safety exists. The US EPA has set Maximum Contaminant Level (MCL) for

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selenium in drinking water at the MCLG of 0.05 mg/L. The utility must take certain steps to correct the problem if the water exceeds the limit and they must notify citizens of all violations of the standard. World Health Organization has set their guideline value for selenium at 0.04 mg/L (WHO, 2011).

## REFERENCES/SOURCES

World Health Organization. Selenium in Drinking Water (2011). Retrieved from:

[http://www.who.int/water\\_sanitation\\_health/dwg/chemicals/selenium.pdf](http://www.who.int/water_sanitation_health/dwg/chemicals/selenium.pdf)

US EPA Basic information about Selenium in Drinking Water. Retrieved from:

<http://water.epa.gov/drink/contaminants/basicinformation/selenium.cfm#eight>

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