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Hexavalent Chromium in Drinking Water: Regulatory Update and Treatment Options

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Hexavalent chromium is a form of the metallic element chromium. Chromium naturally occurs in rocks, animals, plants, soil, and in volcanic dust and gases. It comes in several different forms, including trivalent chromium and hexavalent chromium. Trivalent chromium is often referred to as Chromium (III) and is an essential nutrient for the body. Hexavalent chromium, or Chromium (VI), is generally used or produced in industrial processes, and has been demonstrated to be a human carcinogen when inhaled.

Water sources can be affected by hexavalent chromium naturally or through contamination plumes from industrial centers, landfills, and improper discharge of industrial processing streams. The health effects of hexavalent chromium through ingestion—the dominant exposure route for drinking water—have seen limited study and yielded uncertain conclusions. However, a study conducted by the National Toxicology Program (NTP) that was published in 2007 concluded that hexavalent chromium is carcinogenic when ingested in drinking water. Therefore, utilities and public health officials have begun to investigate the feasibility of reducing hexavalent chromium concentrations in drinking water.

Regulatory Update

The current national drinking water standard, or maximum contaminant level (MCL), for total chromium is 100 micrograms per liter, or parts per billion (ppb), which was raised from the previous level of 50 ppb in 1991. Some states have retained stricter standards. For instance, California's current standard for total chromium is 50 ppb. Total chromium is the combined concentration of all states of the metal chromium, including hexavalent chromium and the less toxic trivalent chromium.

Hexavalent chromium is one of 20 chemicals that are currently being reviewed by the EPA for possible further regulation in drinking water. In September 2010, the EPA issued a draft risk assessment of hexavalent chromium in its Integrated Risk Information System (IRIS) database, which specifically addressed the health risk of hexavalent chromium from ingestion of drinking water. As part of the IRIS process, the toxicological reviews were completed in 2015; however, no other phases of the process have been published to the IRIS website. While the eventual outcomes of the IRIS process could include a more stringent national standard for total or hexavalent chromium, there is no current indication that this is imminent.

The results of the NTP study also triggered the Office of Environmental Health Hazard Assessment (OEHHA) in California to draft a proposed public health goal for hexavalent chromium in drinking water of 0.02 ppb. The public health goal was officially set by OEHHA, and California's Department of Public Health issued a final state MCL for hexavalent chromium of 10 ppb on April 15, 2014. To establish drinking water standards, regulators typically use the results

of toxicological studies like the NTP study to calculate a dose that is meant to protect people from a 70-year lifetime of exposure and to limit the cancer risk to one case in every million people. Regulators also consider the feasibility and costs of removing hexavalent chromium from drinking water before they establish a standard. Although the new standard was immediately effective, Senate Bill No. 385 has since authorized the Board to grant a limited time grace period for water systems to achieve compliance without being considered in violation, as long as compliance plans and strict safeguards are established.

Treatment and Removal

Hexavalent chromium is found more often in ground waters than in surface waters. It can be removed using a handful of proven treatment techniques depending on the level present in the source water, removal goals, other water quality parameters, competing treatment objectives, and treatment waste disposal options. Anion exchange (both strong-base and weak-base), membrane filtration by nanofiltration and reverse osmosis, reduction followed by coagulation and precipitation, and adsorption can remove hexavalent chromium from drinking water. Research conducted by a collaboration of southern California drinking water utilities, EPA, and the Water Research Foundation found that weak-base anion exchange and reduction-coagulation-filtration could remove hexavalent chromium to below 5 ppb for the utilities' particular groundwater source. Other California utilities participating in additional Water Research Foundation studies found that strong-base anion exchange was a viable treatment for their particular water sources, particularly if residuals disposal options were readily available.

WRF Research on Hexavalent Chromium

WRF has conducted the following studies to help utilities understand and address hexavalent chromium removal:

Occurrence Studies

- *Occurrence Survey of Boron and Hexavalent Chromium* (project #2759)
- *Geochemical Controls on Chromium Occurrence, Speciation, and Treatability* (project #2842)

Treatment and Removal Studies

- *Hexavalent Chromium Removal Using Anion Exchange and Reduction With Coagulation and Filtration* (project #3167)
- *Low-Level Hexavalent Chromium Treatment Options: Bench-Scale Evaluation* (project #2814)
- *Impact of Water Quality on Hexavalent Chromium Removal Efficiency and Cost* (project #4450)
- *Hexavalent Chromium Treatment with Strong Base Anion Exchange* (project #4488)
- *Evaluating Reduction Coagulation Filtration and Anion Exchange Brine Optimization for Cr(VI) Removal* (project #4445/4516)

- *Assessment of Single-Pass Ion Exchange, Adsorptive Media, and RCF for Cr(VI) Removal* (project #4423)

The following projects related to Cr(VI) treatment and removal have been funded and are in progress:

- *Scoping Study to Review Contributions of Chromium to Drinking Water from Corrosion in the Distribution System* (project #4562)
- *Cost-Effective Cr(VI) Residuals Management Strategies* (project #4556)
- *Bench-Scale Evaluation of Alternative Cr(VI) Removal Options for Small Systems* (project #4561)

Expert Symposium

- HexChrom 2013 Symposium: This workshop was held February 4, 2013 in Sacramento, California. Presenters provided in-depth information related to the latest developments in health effects research, regulation of hexavalent chromium as a contaminant, treatment techniques, and associated challenges and costs.

Other Helpful Documents

- EPA's basic information page about chromium in drinking water: https://www.epa.gov/dwstandardsregulations/chromium-drinking-water
- California's public health goal for hexavalent chromium, Office of Environmental Health Hazard Assessment: http://oehha.ca.gov/media/downloads/water/chemicals/phg/cr6phg072911_0.pdf
- Information on the National Toxicology Program health effects study: http://www.nih.gov/news/pr/may2007/niehs-16.htm
- National Toxicology Program hexavalent chromium information page: http://ntp.niehs.nih.gov/ntp/factsheets/ntphexavchrmfactr5.pdf