Regulating Hexavalent Chromium in Drinking Water

Bruce A. Macler, PhD
USEPA Region 9
macler.bruce@epa.gov
415 972-3569

The Bottom Line:

Drinking the water from a public supply should be about the safest thing you do

The Safe Drinking Water Act Directs EPA's DW Regulations

- Maximum Contaminant Level Goal
  - Not enforceable, but directs MCL selection
  - "Each MCLG...shall be set at the level at which no known or anticipated adverse effects on the health of persons occur and which allow an adequate margin of safety"
- National Primary Drinking Water Regulations
  - Enforceable
  - Set as close as feasible to MCLGs
  - Feasible analytical methods and treatment technologies
  - Administrator can adjust MCL for cost reasons
- Other regulatory applications generally not considered

Regulatory Construction

- A drinking water regulation needs several things:
- Health risk information
  - Is it a problem at the levels found?
- Suitable quantitative analytical methods
- Occurrence information
  - What levels is it found at?
  - Where, when?
- Feasible treatment technologies
- Holistic cost information (i.e., for everything)
- Benefit-cost analysis (is it worth it?)

Current Chromium Regulatory Status for Drinking Water

- MCL for total chromium [Cr3 + Cr6] is based on Cr6 toxicity
  - USEPA MCL = 100 ug/L
  - California MCL = 50 ug/L
- No federal or state MCL specific for Cr6 alone
- CA proposed Cr6 MCL of 10 ug/L in August 2013
- USEPA reconsidered chromium MCL in recent 6-Year Review, but passed on revision at that time
  - Lacked health, occurrence data that said “change”

Chromium

- Chromium can occur as a metal, or in two ionic forms
  - Trivalent chromium (Cr3), an essential nutrient
  - Hexavalent chromium (Cr6), toxic at high doses
- Chromium in water is mostly naturally occurring
  - Cr3 most common in surface water
  - Cr6 most common in ground water
- USEPA is gathering national occurrence data under the third Unregulated Contaminants Monitoring Rule
  - First cut: total Cr 69% detections at MRL 0.2 ppb
  - Cr6 89% detections above MRL 0.03 ppb

Erin Brockovich, “Erin Brockovich” and Public Perceptions of Cr6

- Pacific Gas and Electric used Cr6 for corrosion control in its cooling towers in Hinkley, CA, and elsewhere
  - Contaminated water got into aquifer
  - PG&E got crosswise with public
- EB championed the issue, helped win a $333M settlement in 1996, got a movie made
- EB led a similar lawsuit in Kettleman City, got them $335M in 2006 settlement (but no sequel)
- Neither case ever argued on merits of toxicity
  - CA DPH epidemiology study showed no health impacts

Glendale, Burbank, LADPW, et al

- Superfund sites in San Fernando Valley for solvents, Cr6 in groundwater
  - Leftovers from aircraft fabrication and other business
- EPA got involved, 1989
  - Three wells with Cr6 >50 ug/L found in 1997
- Glendale, Burbank, LA, CA DTSC, LA Water Master, and LA Regional WQ Control Board formed management group in 1997
- EPA began investigation of Cr6 sources in 1999

Erin Speeds Up Cr6 Activities

- EB got involved at Glendale/Burbank in 2000
- An issue for 2000 election year maneuvers
  - Hearings and media events
  - EB showed her stuff
- CA legislature enacted law in 2001 to require Cr6 MCL
- Glendale city council decided on 5 ug/L Cr6 for city DW
  - Superfund “responsible parties” to pay the costs

Consequences… How Do You Get Cr6 <5 ug/L?

- Glendale, Burbank, LADWP, et al, pooled money and funded WRF treatment project
- Newly-elected Rep Schiff provided series of EPA grants for further treatment research
- Open, flexible R&D process allowed best approaches to emerge
- R&D started small and wide
- Moved to bench and pilot scale as data indicated
- Allowed new questions to get answered

Current Chromium R&D

- Drinking water community fostered needed research
  - Pilot studies on treatment approaches
  - Cost evaluations
  - Treatment residuals management
- Some promising treatment approaches
  - Weak base anion exchange
  - Strong base anion exchange
  - Reduction, coagulation and filtration
- Other CA utilities now doing treatment work
  - Livermore, Davis, Coachella Valley, Soquel Creek, etc

The Evolution of Cr6 Health Risk Assessments

- Trivalent chromium (Cr3) is an essential nutrient
  - Blood sugar control
- Hexavalent chromium (Cr6) is toxic
  - Airborne Cr6 tissue damage, skin sensitization, rashes
  - Cr6 is an oxidant, “burns” tissue
  - Long-term oxidation may yield secondary effects
- 1991 MCL based on RfD with no adverse endpoint
- IRIS RfD (1998) at 3 ug/kg/d (~100 ug/L)
  - Similarly based on no adverse endpoint

Cr6 as a Carcinogen, 1998

- EPA reconsidered carcinogenicity (1998 IRIS)
  - Lung damage from Cr6 plating mists, aerosols
  - Lung cancer in humans from inhalation
  - Probably from oxidation resulting from metabolic reduction of Cr6 to Cr3
- "The oral carcinogenicity of Cr(VI) cannot be determined. No data were located in the available literature that suggested that Cr(VI) is carcinogenic by the oral route of exposure."
- CA OEHHA assumed Cr6 was an oral carcinogen, because of its inhalation carcinogenicity

Evolution of Cancer Risks

- National Toxicology Program studies, 2005-07
  - Tested oral exposure of Cr6 in rats, mice
  - Found elevated mouth and intestinal epithelial neoplasms, starting around 20 mg/L in mice
  - Doses to 180 mg/L did not kill animals
- Rapid reduction from Cr6 to Cr3 occurs in stomach
  - DeFlora, et al (2008) suggested effects threshold as reduction (detoxification) capacity is exceeded

Cr6 Cancer Mode of Action

- Mode of Action (MOA) describes how something could be toxic
- For carcinogens, some can damage DNA, chromosomes directly (genotoxicity)
- Some carcinogens kill cells; healing process can trigger cancer (cytotoxicity)
- CA OEHHA considers Cr6 primarily genotoxic, with no threshold for effects
- Other data indicate that Cr6 cytotoxicity dominates at lower exposures
  - Cytotoxicity has a threshold

Current Cr6 Health Risk Thoughts

- CA OEHHA finalized PHG at 0.02 ug/L on July 27, 2011
- PHG set at “1 cancer per million” risk level
- Did not consider detoxification as risk reduction
- Used linear, no threshold extrapolation
- EPA is reconsidering its risk assessment
- EPA withdrew 2010 draft after peer review
- EPA considering the new data on Mode of Action of carcinogenicity
- Unclear when new draft will appear

CA's Rendezvous with Destiny

- CDPH proposed their Cr6 MCL at 10 ug/L
- Implementation issues will be important
- Treatment will be costly
  - Most of the systems with elevated Cr6 are small GW systems
  - Few, if any, will have Glendale's $uperfunding
  - Water rates would rise markedly for many communities

And USEPA?

- Unlike CDPH, EPA has an option: Revise the current chromium MCL
  - Groundwater is mostly Cr6
  - Surface water is mostly Cr3
- Because of possible oxidation during treatment or in distribution systems (Cr3 -> Cr6), revising total Cr MCL downwards might be best
- EPA will await full data from UCMR3
- Also needs completion of health risk review
- Any decision is a long ways off