Chlorate, currently included in the US Environmental Protection Agency’s (USEPAs) monitoring of unregulated contaminants and on the contaminant candidate list, could potentially move into the regulatory process in the near future. This article, using available literature along with past and current monitoring data, assesses the presence of chlorate in drinking water and the potential impact of its regulation. This article gives specific attention to the variety of threshold concentrations that appear most often in the literature—210, 700, and 840 µg/L—and evaluates the effect a regulatory requirement for each of these values would have on utilities. The research indicated that potential regulatory thresholds > 700 µg/L would be violated only by < 10% of utilities. The effects of regional conditions and type of disinfection used depend greatly on the adopted thresholds. Utilities in the southern region of the United States and utilities using chloramination are most at risk if a low maximum contaminant level (MCL) is adopted.

Chlorate occurs in drinking water as a result of chlorine products used in treatment. Common sources of chlorate are the degradation of hypochlorite solutions, the on-site generation of hypochlorite, and the production and degradation of chlorine dioxide. Chlorate has periodically been considered for regulation since the early 1990s, when it was part of the negotiated rulemaking for the proposed Stage 1 Disinfectants and Disinfection Byproducts (D/DBP) Rule (USEPA, 1994). Chlorate was not included in the final Stage 1 D/DBP Rule because the health effects data at that time were inadequate to establish an MCL Goal (USEPA, 1998). However, chlorate is currently being discussed again for potential regulation.

Section 1412(b)(1)(A) of the Safe Drinking Water Act details three criteria that USEPA must consider in identifying new contaminants for potential regulation and in making regulatory determinations:

1. The contaminant may have an adverse effect on the health of persons.

2. The contaminant is known to occur or there is a substantial likelihood that the contaminant will occur in public water systems with a frequency and at levels of public health concern.

3. In the sole judgment of the Administrator, regulation of such contaminants presents a meaningful opportunity for health risk reduction for persons served by public water systems.

This article summarizes existing data related to the first two of these criteria—health effects and occurrence. This article also summarizes existing data on chlorate analytical methods, treatment, and control, all of which would be additional considerations for USEPA in developing a potential chlorate MCL.

Contaminant thresholds are based on a calculated reference dose (RfD) resulting from experimental studies, a standard body weight, a standard volume of intake, and the relative source contribution (RSC), or the fraction of the RfD a person receives from drinking water. In USEPA’s calculations of a health reference level (HRL) for chlorate, the benchmarks used in initial evaluations of occurrence were an RfD of 0.03 mg/kg/d, based on a chronic toxicity study in rats (USEPA, 2006; NTP, 2005), and a default RSC of 20%, resulting in an HRL of 210 µg/L. However, the major exposure to chlorate comes from drinking water, suggesting that an RSC of 80% is more appropriate. Simply adjusting the RSC to 80% increases the HRL to 840 µg/L (Cotruvo, 2014) and would result in significantly fewer utilities potentially being out of compliance.

CHLORATE OCCURRENCE IN DRINKING WATER

The first comprehensive set of monitoring data for chlorate came from the 1996 Information Collection Rule (USEPA, 1996). Monitoring to create a national ICR database was conducted from July 1997 to December 1998 (USEPA, 2011). More recently, chlorate was included in monitoring under the 2012–2015 Third Unregulated Contaminant Monitoring Rule (UCMR 3), projected to finish by December 2015 (USEPA, 2012). USEPA is updating and posting summaries of the UCMR 3 monitoring results on a regular basis (USEPA, 2014a). The July 2014 release of UCMR 3 data was used in this research. USEPA is using the term “reference concentration” rather than HRL in its UCMR 3 reporting, but the reference concentration of 210 µg/L is the same threshold concentration as the previous HRL. The data available for this analysis, both ICR data and the July 2014 release of UCMR 3 data, are summarized in Table 1. Approximately 15% of the samples for both datasets were above the HRL of 210 µg/L, and only 1% were greater than the higher 840-µg/L HRL calculated by Cotruvo (2014).

Analysis of the UCMR 3 data showed that chloramination practices correlate not only the highest potential chlorate concentrations but also the largest variability in chlorate concentrations. These results indicate that it is extremely important for utilities to monitor the disinfection...
process and control unwanted by-products. More than 40% (31 utilities) of the systems with chlorate values > 840 µg/L used hypochlorite that was generated off site. Only four utilities practicing on-site hypochlorite generation measured chlorate concentrations > 840 µg/L.

Although chlorine gas produces the lowest concentrations of chlorate in treated water, heightened security concerns since 9/11 and the regulatory requirements for risk-management plans in Section 112(r) of the Clean Air Act are causing many utilities to move away from chlorine gas. In a 2007 survey of water utility disinfection practices, 25% of the utilities surveyed planned to switch from chlorine gas to hypochlorite (either bulk or on-site generation) in the future (AWWA, 2008a, 2008b). As utilities continue to switch from chlorine gas to another chlorine-based process for security purposes, the residual chlorate concentrations in treated water are likely to increase.

REGULATORY CHALLENGES RELATED TO CHLORATE

In its October 2014 announcement of the Preliminary Regulatory Determinations for Contaminants on the Third Drinking Water Contaminant Candidate List, USEPA stated that a regulatory determination for chlorate would not be made at that time because chlorate is to be included in the intended review of DBPs in 2016 (USEPA, 2014b). USEPA cites the argument that DBPs must undergo evaluation collectively in order for any potential regulatory action to be determined; therefore, a chlorate regulatory determination is now tied to the question of whether the Microbial and Disinfection Byproducts Regulations should be revised. As a result, the agency could face its own regulatory challenges, depending on the threshold value used in the development of a potential chlorate MCL. An MCL of 210 µg/L would significantly increase the nationwide cost of compliance compared with an MCL in the range of the World Health Organization’s guideline of 700 µg/L.

Even with uncertainties about the schedule, the compliance determination, and the final MCL, utility officials should consider taking steps to better understand the chlorate levels in their water systems. Chlorate presents some unique compliance challenges for water systems because no routine treatment technology exists for removing it. Though almost all regulated drinking water contaminants can be removed by one or more existing treatment technologies, the key to complying with a potential chlorate regulation is to prevent the compound’s formation. Although some mitigation techniques are being explored for systems that generate hypochlorite on site, most of the control strategies revolve around proper storage and handling of bulk hypochlorite and carefully controlled production of chlorine dioxide.

REFERENCES


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TABLE 1 Summary of ICR and UCMR 3 data

<table>
<thead>
<tr>
<th>Monitoring Results</th>
<th>ICR Data* Number—%</th>
<th>UCMR 3 Data† Number—%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samples</td>
<td>897</td>
<td>25,533</td>
</tr>
<tr>
<td>Systems</td>
<td>82</td>
<td>2,648††</td>
</tr>
<tr>
<td>Systems &gt; MRL‡</td>
<td>747 (83)</td>
<td>14,356 (56)</td>
</tr>
<tr>
<td>Systems &gt; MRL‡</td>
<td>80 (98)</td>
<td>1,781 (67)</td>
</tr>
<tr>
<td>Samples &gt; 210 µg/L</td>
<td>135 (15)</td>
<td>3,671 (14)</td>
</tr>
<tr>
<td>Systems &gt; 210 µg/L</td>
<td>31 (38)</td>
<td>857 (32)</td>
</tr>
<tr>
<td>Samples &gt; 700 µg/L</td>
<td>17 (21)</td>
<td>344 (1.3)</td>
</tr>
<tr>
<td>Systems &gt; 700 µg/L</td>
<td>4 (5)</td>
<td>174 (7)</td>
</tr>
<tr>
<td>Samples &gt; 840 µg/L</td>
<td>12 (1)</td>
<td>203 (0.8)</td>
</tr>
<tr>
<td>Systems &gt; 840 µg/L</td>
<td>4 (5)</td>
<td>118 (4)</td>
</tr>
</tbody>
</table>

ICR—Information Collection Rule, MRL—maximum reporting level, UCMR 3—Unregulated Contaminant Monitoring Regulation 3 for Public Water Systems
*Finished water samples only
†Distribution system entry point and other monitoring samples as of July 2014
‡Representation of 55–60% of the systems expected to report data under the UCMR 3
§Both databases have a 20-µg/L MRL.

Systems were evaluated using the utility’s maximum reported concentration.