Status of Chlorate Regulation in the United States

Chlorate formation as a result from water disinfection with bulk sodium hypochlorite, chlorine dioxide, or electrochemically produced sodium hypochlorite

Chlorate (ClO_3^-) was added to the Third Chemical Contaminant List (CCL3) in 2010, indicating that the Environmental Protection Agency (EPA) is reviewing chlorate as a potential candidate for regulation under the Safe Drinking Water Act. While there is no indication that chlorate is a potential carcinogen to humans, negative health impacts such as thyroid issues, reduced hemoglobin production, and reduced weight gain have been observed in laboratory animals subjected to prolonged exposure to chlorate.[1, 2, 4]

Chlorate is a highly oxidized form of chlorine that can be introduced to a water source as an industrial or agricultural contaminant or into a finished water as a disinfection byproduct (DBP). As a DBP, chlorate can result from water disinfection with bulk sodium hypochlorite, chlorine dioxide, or hypochlorite formed through electrolytic on-site generation (OSG) systems.

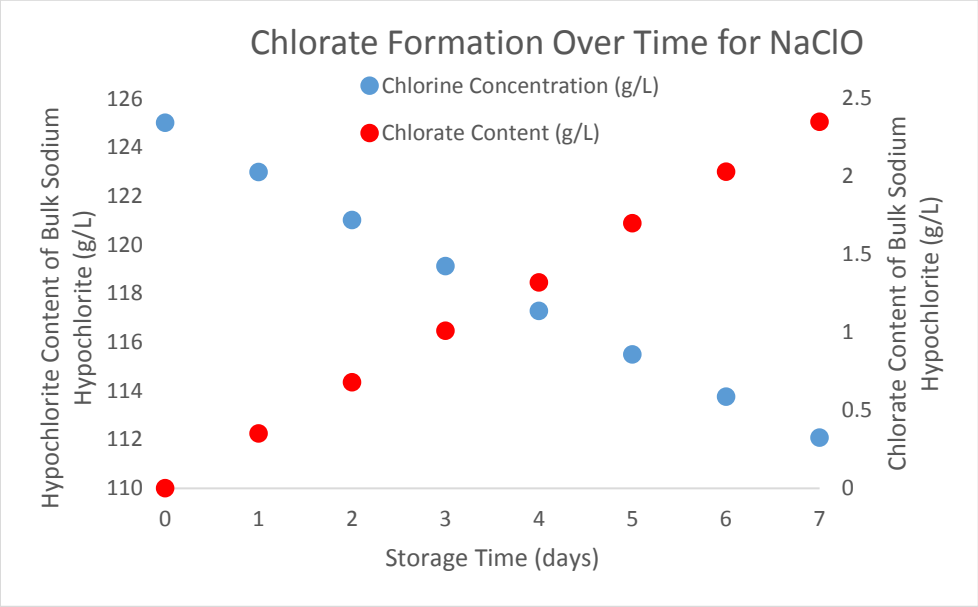
Regulatory Status

Currently, chlorate in drinking water is not regulated in the United States and there is no enforceable Maximum Contaminant Limit (MCL). In Canada, chlorate is regulated at concentration of 1.0 mg/L (1000 µg/L). The World Health Organization (WHO) recommends a chlorate limit of 0.7 mg/L (700 µg/L).[2, 4] While no final recommendation has been promulgated, literature on the topic indicates that the regulation may fall within the range of 0.21 mg/L (210 µg/L) to 0.8 mg/L (800 µg/L) in the US. While the EPA has established 210 µg/L as a health reference level (HRL), it is conjectured that the EPA will not set regulation at such a low level as it will seriously impact the viability of using delivered bulk hypochlorite for disinfection.

Impact on Water Treatment Plants Using Delivered Sodium Hypochlorite

Several studies have been conducted by researchers regarding the occurrences of chlorate in drinking water and the factors that influence chlorate introduction. With regard to delivered hypochlorite, chlorate mainly arises as a degradation product of hypochlorite ions. Hypochlorite degradation is exacerbated by several factors, including the following:

- Freshness of solution – older hypochlorite solutions will have higher relative chlorate concentrations.



- Concentration of delivered solution – higher concentration hypochlorite solutions degrade more rapidly than lower concentration solutions.
- Storage temperature – higher temperatures increase the rates of hypochlorite degradation and chlorate production.

Because of the above factors, some water treatment plants will struggle with using bulk hypochlorite depending on how fresh they can purchase the product from chemical manufacturers and how quickly they can use the solution. If chlorate is regulated as a DBP, most utilities that use bulk hypochlorite will have to significantly alter their use of this chemical to avoid exceeding the regulatory limits, and these changes will result in a substantial increase in operational costs. Operational changes may include, but are not necessarily limited to:

- Cooling of the room where the hypochlorite is stored to slow hypochlorite degradation.
- Requiring "born-on dating" labeling from the manufacturers.
- Limiting storage volumes.
- Purchasing lower concentrations to slow hypochlorite degradation.
- Dilution of the concentrated hypochlorite once it has been delivered to the treatment plant.

Any of these operational adaptations can be expected to create significant hardship for water treatment plant operators since they would involve increased logistical complexities as well as higher operating costs. These impacts would be felt the most for the lowest chlorate MCLs that are being contemplated.

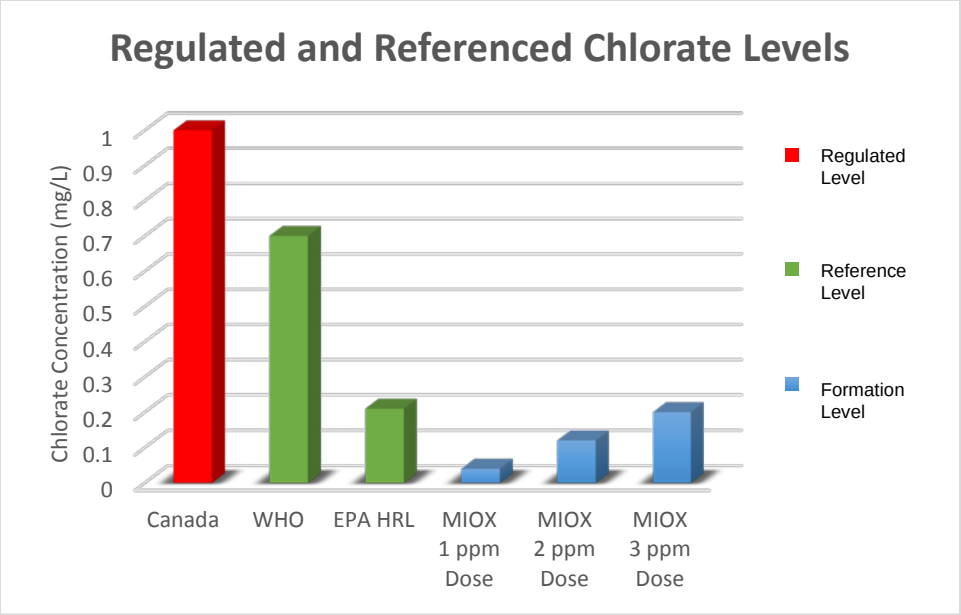
Unique Benefits of MIOX On-Site Generation

In an effort to prepare for likely regulation of chlorate, water treatment plant operators as well as industrial water quality managers have begun to investigate viable approaches to "future-proof" their disinfection chemistries. Fortunately, MIOX OSG systems present an ideal to this challenge due to the following reasons:

1. Chlorate formation from hypochlorite solutions generated by MIOX electrolysis is well below proposed regulatory levels.

   Currently, if chlorate is regulated, the EPA has contemplated that they would likely be set at or near the international WHO guideline of 0.7 mg/L (700 µg/L). Extensive testing on the chlorate production by MIOX's RIO OSG systems has been undertaken both internally and in conjunction with third party studies. Typically, the MIOX systems produce chlorate at a rate of less than 40 micrograms (0.04 mg) per milligram of free available chlorine (FAC).

   Therefore, even at a high FAC dose of 5 mg/L, the expected chlorate concentration in the treated water will be less than 200 µg/L (0.2 mg/L), which is well below the likely 700 µg/L limit and is even below the EPA health reference limit of 210 µg/L. Typically, water treatment plants only dose 2 – 3 mg/L as free available chlorine, and at these dose points, chlorate content in the finished water will likely be half of the lowest contemplated chlorate regulatory limit.



2. Since the hypochlorite solution is generated on-site, as needed, storage time is typically 24 hours or less, which minimizes hypochlorite degradation.

3. In addition, the hypochlorite solution is generated at less than 1% chlorine concentration, which also reduces the chorine degradation rate.

Conclusion

MIOX is in an enviable position for any future chlorate regulations that may be implemented as:

- A variety of factors influence chlorate formation, there is no single one cause.
- MIOX understands many of the factors involved in the production of chlorate during sodium chloride brine electrolysis.
- MIOX has developed the technological means to control and influence these factors.
- Chlorate formation can be controlled to extremely low levels for markets and applications looking to introduce as little chlorate as possible into treated water.
- Features allowing for chlorate minimization can be retrofitted to existing OSG systems.

Many industrial applications already desire much lower chlorate levels in treated water, primarily in the food and beverage industry. In these cases, operators have found it impossible to meet their goals with delivered hypochlorite, and have turned to MIOX for a solution. Based on this driving force, MIOX has been working over the last several years to understand how chlorate is produced during electrolysis and has developed operations and technologies capable of addressing the stringent requirements of these industries. Even though the municipal regulations will likely never get as low as industrial goals, MIOX will have OSG systems that will meet the most stringent of requirements.
For customers looking to “future-proof” their disinfection processes, MIOX is the most cost effective and reliable option. MIOX systems are already the lowest cost option for disinfection in the marketplace, and they will only be more so if chlorate regulations create cost increases for the use of delivered hypochlorite.

Future regulations should be no cause for concern for current projects existing MIOX customers can be rest assured that they will not be stuck with a non-compliant disinfection approach.

1) Perchlorate, bromate, and chlorate in hypochlorite solutions: Guidelines for Utilities, BD Stanford, AN Pisarenko, SA Snyder, G Gordon. *Journal AWWA*, **2011**, *103 (6)*, p 71.

2) Chlorate Challenges for Water Systems, K Alfredo, B Stanford, JA Roberson, A Eaton. *Journal AWWA*, **2015**, *107 (4*), p E187

3) Chlorate, Perchlorate, and Bromate in Onsite-Generated Hypochlorite Systems, BD Stanford, DJ Dryer, JC Zeigler-Holady, S Gamage, O Quiñones, *Journal AWWA,* **2013** *105 (3*), p E93.

4) The Potential Regulatory Implications of Chlorate, K. Alfredo, C. Adams, A. Eaton, J. A. Roberson, B. Stanford. Published by the American Water Works Association, **2014**.

5) Six-Year Review 3 Technical Support Document for Chlorate, Office of Water (4607M), EPA-810-R-16-013, December **2016**.

6) Chlorite and Chlorate in Drinking-water - Background document for development of WHO Guidelines for Drinking-water Quality, WHO/SDE/WSH/05.08/86, **2005**.