Sodium Hypochlorite

NaOCl (liquid)

Direct Use Chemical

Inputs to Manufacturing Process:
Chlorine
Sodium Hydroxide

% of Total Domestic Consumption Attributed to Water Sector:
Less than 10%

Product Family:
Chlor-alkali

CAS No.:
7681-52-9

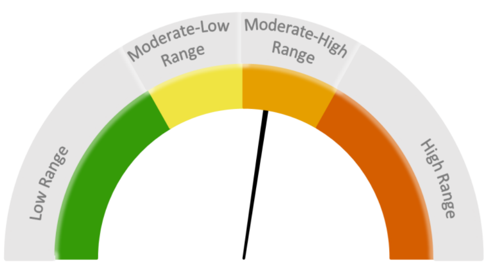
Derivative Water Treatment Chemicals:
None

Understanding Chemical Supply Chains
Map of Suppliers & Manufacturers

Shelf Life:
1 Month

RISK OF SUPPLY DISRUPTION (Assessed in 2022)

RISK RATING: Moderate-High



RISK DRIVERS

Production of sodium hypochlorite depends on the chlor-alkali industry to produce the inputs used to manufacture it. Unplanned and planned reductions in chlor-alkali production capacity have reduced the supply of sodium hypochlorite.

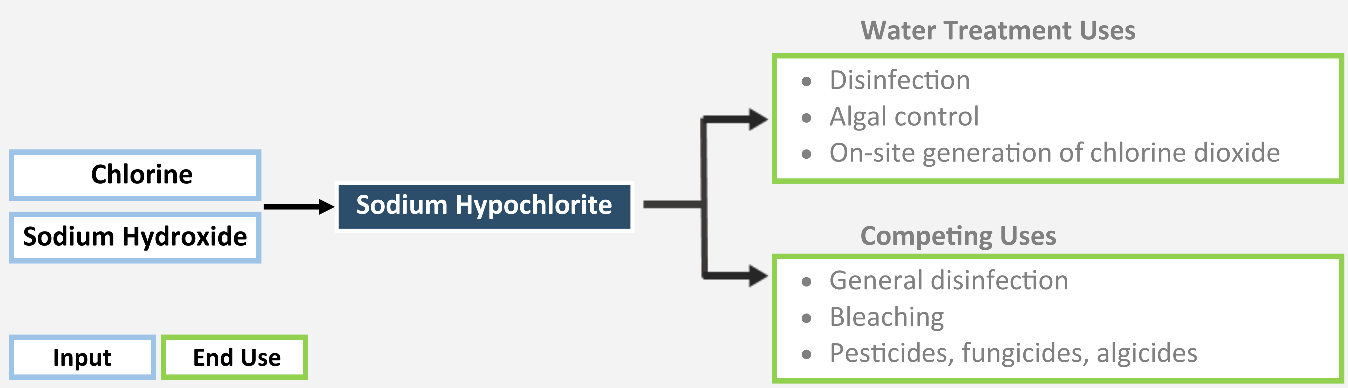
RISK PARAMETERS

Criticality: High. Essential for water disinfection.

Likelihood: High. Previous widespread disruptions in supply that impacted the water sector.

Vulnerability: Low. Distributed domestic manufacturing and supply.

MANUFACTURING PROCESS



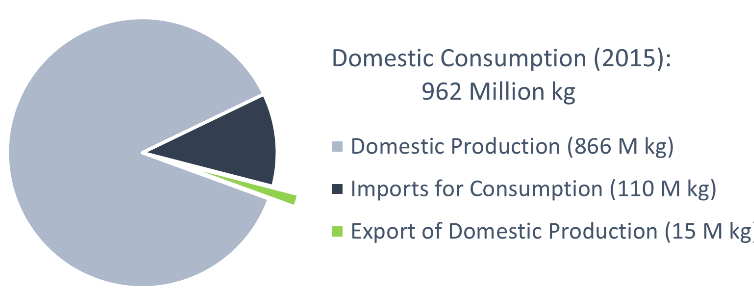
DOMESTIC PRODUCTION AND CONSUMPTION, AND INTERNATIONAL TRADE

Domestic Manufacturing Locations (2015):
91, distributed throughout the U.S.

International Trade (2019)

Primary Trading Partner (Imports): Canada

Primary Trading Partner (Exports): Canada



Product Description

Sodium hypochlorite (NaOCl), an inorganic chemical and strong oxidant, is a widely used water disinfectant. It is a derivative product of the chlor-alkali industry, primarily manufactured through the reaction of sodium hydroxide solution with chlorine. The majority of sodium hypochlorite manufactured in the U.S. is used in cleaning and general disinfection applications.

Use in Water Treatment

Sodium hypochlorite has several uses in water treatment, including primary and residual disinfection, algal control, and on-site generation of chlorine dioxide (AWWA, 2018).

Use as a Precursor to Other Water Treatment Chemicals

Sodium hypochlorite is not used to manufacture other water treatment chemicals.

Other Applications

Sodium hypochlorite is widely used in many industries and a variety of settings as a general disinfectant and bleaching agent. It is also used in semiconductor manufacturing, and formulating pesticides, fungicides, and algicides (NCBI, 2020).

Primary Industrial Consumers

Sodium hypochlorite is primarily used for cleaning and disinfection across a wide range of industries and applications.

Manufacturing, Transport, & Storage

Manufacturing Process

Chlorine and sodium hydroxide are the most common starting materials used to produce sodium hypochlorite, as illustrated by the equation shown in Figure 1. The production of sodium hypochlorite is often co-located at chlor-alkali manufacturing facilities where chlorine and sodium hydroxide are produced. Sodium hypochlorite is also produced in facilities designed specifically for its production, which procure chlorine and sodium hydroxide from chlor-alkali manufacturing facilities or their distributors. Manufacturing takes place by one of two methods: the batch method or continuous method. The continuous method is more prevalent in domestic manufacturing. In the continuous process, gaseous chlorine is injected into a dilute sodium hydroxide solution. The automated continuous process avoids over-chlorination and leads to production of a stable solution by controlling the ratio of chlorine to sodium hydroxide to allow for excess sodium hydroxide that is necessary to stabilize the final solution. Sodium hypochlorite and sodium chloride are produced in equal amounts in addition to water through this reaction (Olin Corporation, 2019; NCBI, 2020; The Chlorine Institute, 2017). The general equation for this process is shown in Figure 1.

$$\text{Chlorine} + \text{Sodium Hydroxide} \rightarrow \text{Sodium Hypochlorite} + \text{Sodium Chloride} + \text{Water}$$

$$Cl_2 + 2NaOH \rightarrow NaOCl + NaCl + H_2O$$

Figure 1. Chemical Equation for the Reaction to Manufacture Sodium Hypochlorite

Additionally, sodium hypochlorite can be produced using a "brine to bleach" process, which uses electrolysis of brine in a process similar to that used by the chlor-alkali production facilities (Odyssey Manufacturing, 2022). However, the majority of sodium hypochlorite produced for the commercial market occurs using the process described in Figure 1.

While most sodium hypochlorite used in water treatment is manufactured off-site, some water treatment facilities choose to generate sodium hypochlorite onsite. The process for onsite generation requires sodium chloride and softened or deionized water to produce a brine that is passed through an electrolytic cell to generate sodium hypochlorite. The sodium hypochlorite is then stored in a separate tank and metered into the water (PSI Water Technologies, 2020).

Product Transport

The geographic market for distribution is limited by the expense of transporting sodium hypochlorite. Generally, the maximum distance for truck transport considered to be economically efficient is approximately 250-300 miles from the point of production (FTC, 2013). Bulk transport by rail is very significant and allows for manufacturing locations to meet wide geographic distribution (Olin Corporation, 2019).

Storage and Shelf Life

Sodium hypochlorite solution should be stored in tightly closed containers and kept in a cool place away from the direct sunlight. When stored properly, sodium hypochlorite can have a shelf life of approximately 1 month, depending on temperature, pH, concentration, presence of impurities, and size of storage container. Storage durations beyond recommended shelf life can lead to product degradation and loss of efficacy (Olin Corporation, 2019; CDC, 2014).

Domestic Production & Consumption

Domestic Production

Production data was collected from the 2016 EPA Toxic Substances Control Act (TSCA) Chemical Data Reporting (CDR) for the year 2015[1], while trade data was collected from the U.S. International Trade Commission (USITC) Dataweb, as shown in Table 1. While production data is specific to sodium hypochlorite, trade data includes sodium hypochlorite as part of the category for hypochlorites, chlorites, and hypobromites.

Table 1. Sodium Hypochlorite Production and Trade Data Sources

Production and Trade Data			
Category	**Data Source and Date**	**Identifier**	**Description**
Domestic Production	2020 TSCA Chemical Data Reporting	CAS No.: 7681-52-9	Sodium Hypochlorite
Imports and Exports	U.S. International Trade Commission	HS Code: 2828.90	Hypochlorites, Chlorites, and Hypobromites

Total U.S. domestic manufacturing of sodium hypochlorite reported under the CDR was approximately 886 million kilograms (M kg) in 2015; however, several leading manufacturers (i.e., *Olin, Univar*) claimed confidential business information and did not report production volumes to EPA (EPA, 2016). Domestic commercial manufacture of sodium hypochlorite takes place at many facilities located throughout the contiguous U.S., including chlor-alkali facilities, traditional bleach production facilities, and brine-to-bleach facilities. Thus, there are more production locations for sodium hypochlorite than there are production locations for chlor-alkali chemicals. Most sodium hypochlorite production facilities rely on the availability of the chlor-alkali co-products chlorine and sodium hydroxide. The number of domestic manufacturing locations shown in Figure 2 represents operating facilities as of 2019 (The Chlorine Institute, 2020). Supply of NSF/ANSI Standard 60 certified sodium hypochlorite for use in drinking water treatment is widely distributed throughout the U.S. (NSF International,

[1] Although 2019 CDR data is available, reporting is less complete when compared to 2015 data due to an increase in the number of companies claiming confidential business information (CBI). In both instances, CBI may account for a significant volume of sodium hypochlorite produced that is not reflected in CDR reporting.

2021). For a more current listing of manufacturing locations and supplier locations, visit the U.S. Environmental Protection Agency's (EPA's) Chemical Locator Tool (EPA, 2022a).

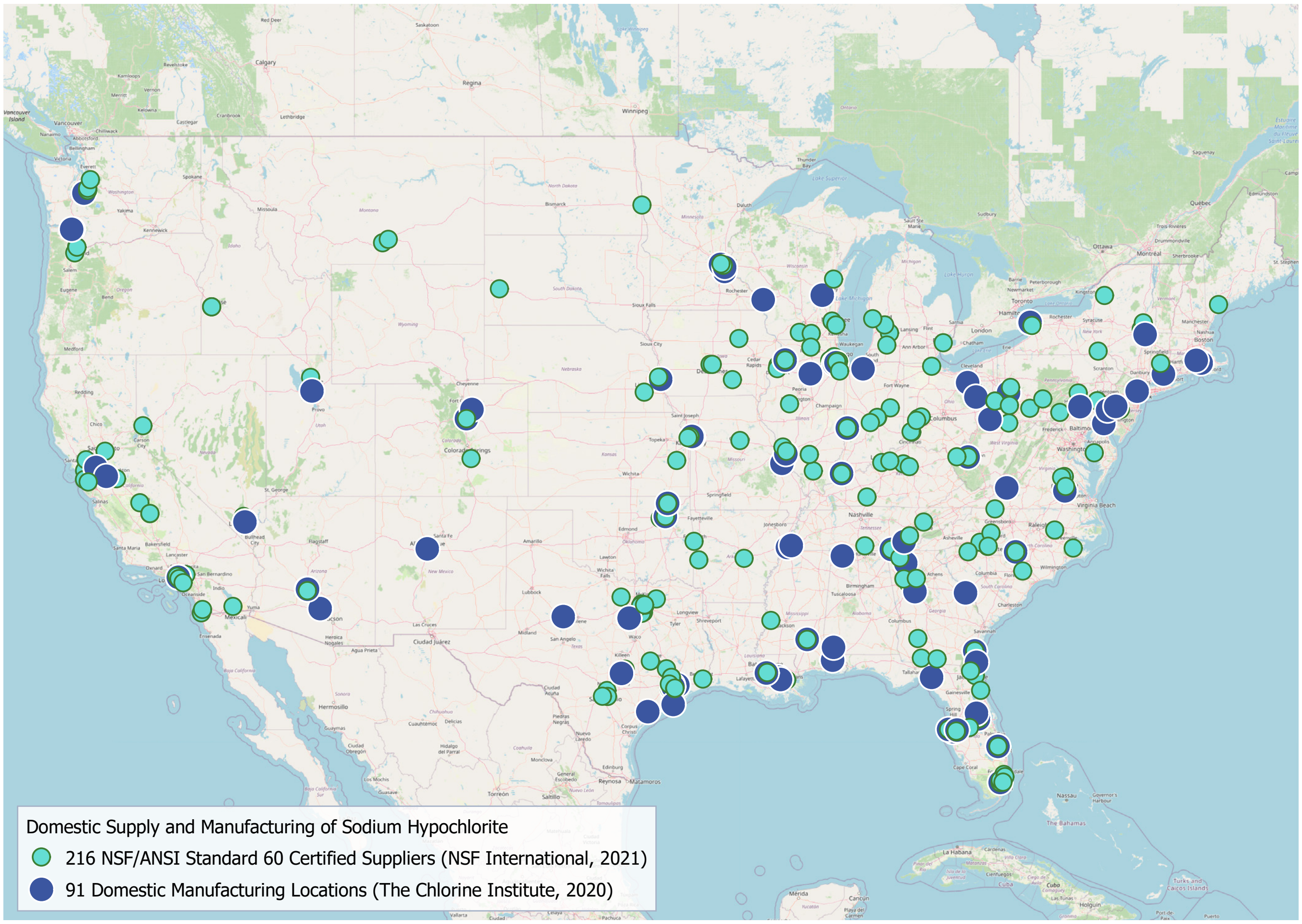


Figure 2. Domestic Supply and Manufacturing of Sodium Hypochlorite

Domestic Consumption

U.S. consumption of sodium hypochlorite in 2015 is estimated at 962 M kg. This estimate includes production of 866 M kg, import of 110 M kg, minus export of 15 M kg (EPA, 2016; USITC, 2021), as shown in Figure 3. Imports and exports represent small quantities when compared to domestic production.

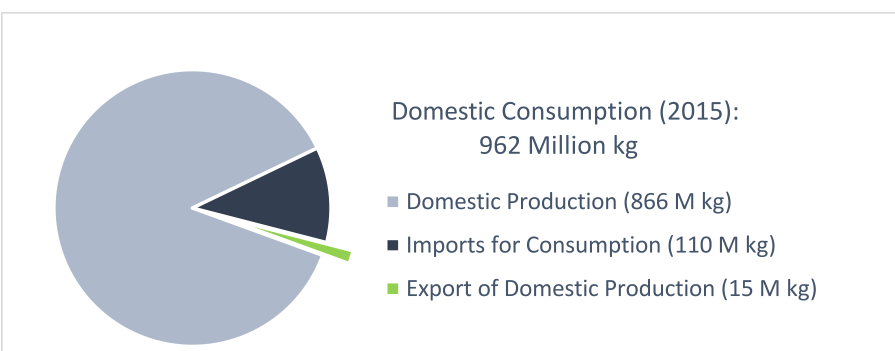


Figure 3. Domestic Production and Consumption of Sodium Hypochlorite in 2015

Trade & Tariffs

Worldwide Trade

Worldwide import and export data for sodium hypochlorite are reported through the World Bank's World Integrated Trade Solutions (WITS), as a category representing a class of compounds including hypochlorites, chlorites, and hypobromites. In 2021, the U.S. ranked eighth worldwide in total exports and first in total imports of hypochlorites, chlorites, and hypobromites. In 2021, China ranked first worldwide in total exports (WITS, 2022), as shown in Table 2. Import and export data specific to sodium hypochlorite is unavailable from the referenced sources.

Table 2. WITS Worldwide Export and Import of Hypochlorites, Chlorites, and Hypobromites, Including Sodium Hypochlorite, in 2021

2021 Worldwide Trade Hypochlorites, Chlorites, and Hypobromites (HS Code 2828.90)			
Top 5 Worldwide Exporters		Top 5 Worldwide Importers	
China	156 M kg	**United States**	**133 M kg**
Canada	131 M kg	France	74 M kg
Belgium	87 M kg	Canada	56 M kg
Spain	83 M kg	Germany	54 M kg
Germany	72 M kg	Italy	47 M kg

Domestic Imports and Exports

Domestic imports and export data are reported by USITC in a category including all hypochlorites, chlorites, and hypobromites. Figure 4 summarizes imports for consumption[2] and domestic exports[3] of hypochlorites, chlorites, and hypobromites between 2015 and 2020. During this period, the overall quantity of exports and imports remained relatively steady, with imports for consumption exceeding domestic exports. Over this five-year period, Canada was the primary recipient of domestic exports and the primary source of imports (USITC, 2021).

[2] Imports for consumption are a subset of general imports, representing the total amount cleared through customs and entering consumption channels, not anticipated to be reshipped to foreign points, but may include some reexports.
[3] Domestic exports are a subset of total exports, representing export of domestic merchandise which are produced or manufactured in the U.S. and commodities of foreign origin which have been changed in the U.S.

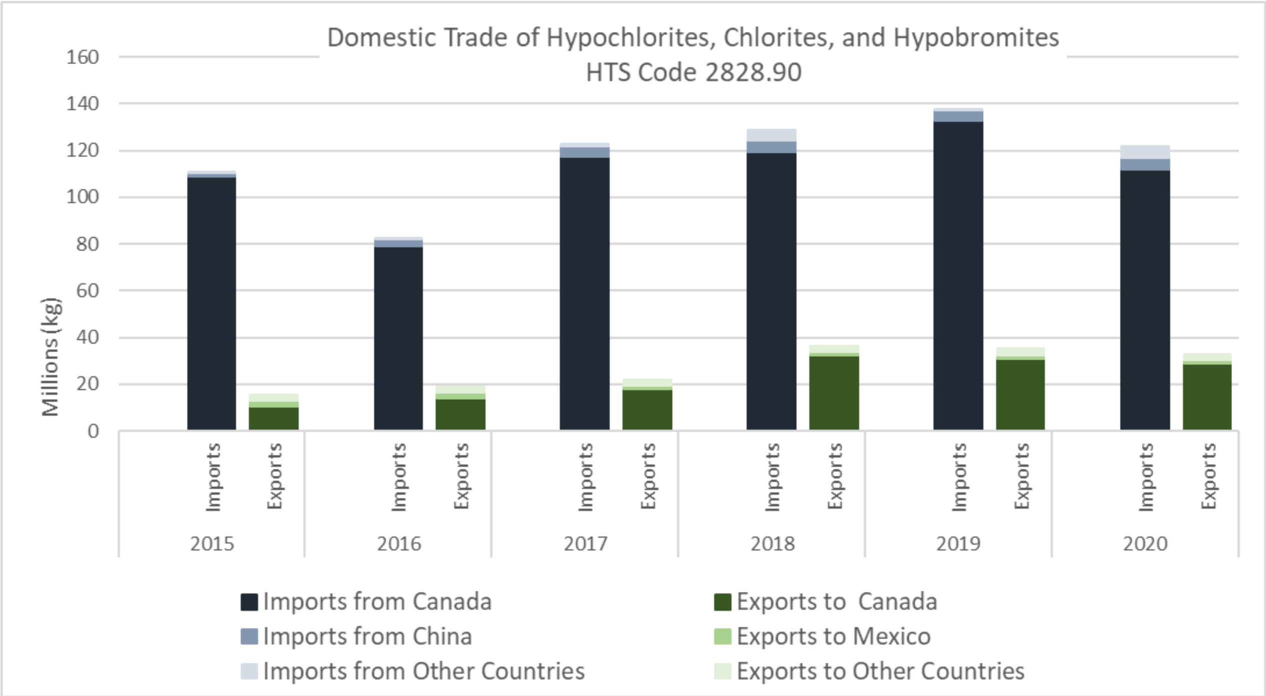


Figure 4. USITC Domestic Import and Export of Hypochlorites, Chlorites, and Hypobromites between 2015 and 2020

Tariffs

There is a 3.7% general duty for import of sodium hypochlorite, and an additional 25% duty on imports from China (USITC, 2022), as summarized in Table 3.

Table 3. 2021 Domestic Tariff Schedule for Sodium Hypochlorite

HS Code	General Duty	Additional Duty - China (Section 301 Tariff List)	Special Duty
2828.90	3.7%	25%	Free (A, AU, BH, CA, CL, CO, D, E, IL, JO, KR, MA, MX, OM, P, PA, PE, SG)[4]

Market History & Risk Evaluation

History of Shortages

During the COVID-19 pandemic there was a significant increase in the demand for many chlorine derivative products due to increased disinfection of buildings, equipment, surfaces, etc. in an effort to reduce the spread of COVID-19. Concurrent with this increased demand, there was a temporary loss of approximately 28% of domestic chlor-alkali production capacity when Winter Storm Uri directly hit the Gulf Coast region in February 2021 (The Chlorine Institute, 2021). Furthermore, in spring and summer of 2021, a number of chlor-alkali production facilities experienced significant equipment failures resulting in additional, temporary losses in production capacity. While some of these impacted facilities were located in the Gulf Coast region, others were located in West Virginia, Utah, and Washington. Later in the summer of 2021, there was a permanent reduction in chlor-alkali production capacity at facilities located in New York, Alabama, Louisiana, and Texas. The reductions in chlor-alkali production capacity that occurred in 2021 were compounded by the impacts of COVID-19 (Powder and Bulk Solids, 2021; Prohaska, 2021). Changes to domestic chlor-alkali production are known to

[4] Symbols used to designate the various preference programs and trade agreements. A full list of special trade agreements and associated acronyms can be found at https://help.cbp.gov/s/article/Article-310?language=en_US and the General Notes Section of the Harmonized Tariff Schedule https://hts.usitc.gov/current

have a direct impact on the availability of chlorine and derivative products available for domestic consumption, since imports represent a small fraction of overall chlorine consumption (Kreuz et al., 2022). This was exemplified by decreased allocations of chlorine and sodium hypochlorite for drinking water and wastewater systems in California, Oregon, Washington, Alaska, Utah, Missouri, Ohio, Pennsylvania, New York, Massachusetts, Louisiana, and Florida, as reported directly to EPA.

A threatened rail carrier work stoppage in September 2022 highlighted the dependence of the domestic chlorine supply chain on a complex national rail network for producers, suppliers, and end-users. Due to the concentration of chlor-alkali facilities along the Gulf Coast combined with widespread need for chlorine, long-distance transport of chlorine is often required. Additionally, a significant number of domestic manufacturers of derivative water treatment chemicals are almost exclusively reliant on rail delivery of chlorine for production needs (Branscomb et al., 2010).

Risk Evaluation

The complete risk evaluation methodology is described in *Understanding Water Treatment Chemical Supply Chains and the Risk of Disruptions* (EPA, 2022b). The risk rating is calculated as the product of the following three risk parameters:

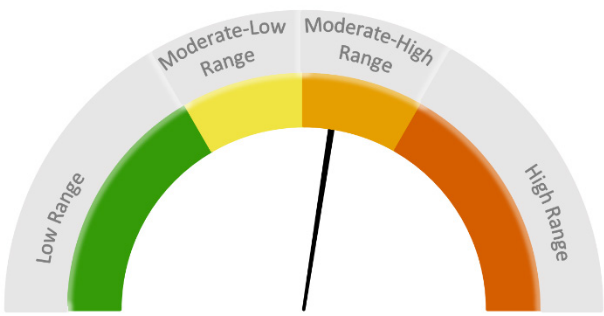
Risk = Criticality x Likelihood x Vulnerability	
Criticality	Measure of the importance of a chemical to the water sector
Likelihood	Measure of the probability that the chemical will experience a supply disruption in the future, which is estimated based on past occurrence of supply disruptions
Vulnerability	Measure of the market dynamics that make a chemical market more or less resilient to supply disruptions

The individual parameter rating is based on evaluation of one or more attributes of the chemical or its supply chain. The ratings and drivers for these three risk parameters are shown below in Table 4.

Table 4. Supply Chain Risk Evaluation for Sodium Hypochlorite

Risk Parameter Ratings and Drivers		
Criticality — High	**Likelihood — High**	**Vulnerability — Low**
Sodium hypochlorite is essential and has widespread application as a disinfectant in both drinking water and wastewater treatment.	The water sector has experienced widespread sodium hypochlorite supply disruptions in the past. In 2021 disruption in the supply of sodium hypochlorite occurred due to an increase in demand due to the COVID-19 pandemic and a decrease in supply of precursors (primarily chlorine) as a result of both temporary losses in chlor-alkali production capacity due to equipment failures and extreme weather events, and permanent, planned reductions in production capacity.	Strong domestic manufacturing capabilities and a distributed manufacturing base provide some resilience to supply disruptions. However, chlor-alkali facility closures in 2021 and the potential for future losses in production capacity could increase vulnerability.

Risk Rating: Moderate-High



References

American Water Works Association (AWWA), 2018. *B300, Hypochlorites*. Denver, CO: American Water Works Association.

Branscomb, L., Fagan, M., Auerswald, P.E., Ellis, R. and Barcham, R., 2010. Rail Transportation of Toxic Inhalation Hazards: Policy Responses to the Safety and Security Externality. Harvard Kennedy School of Government. Retrieved from https://www.hks.harvard.edu/sites/default/files/centers/taubman/files/Fagan_UTC20_working_paper_2010.pdf

Center for Disease Control (CDC), 2014. Frequently Asked Questions (FAQs) about Sodium Hypochlorite Solution(SH), retrieved from https://www.cdc.gov/healthywater/global/household-water-treatment/chlorination-faq.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fsafewater%2Fchlorination-faq.html

EPA, 2016. 2016 TSCA Chemical Data Reporting, retrieved from https://www.epa.gov/chemical-data-reporting/access-cdr-data#2016

EPA, 2022a. Chemical Suppliers and Manufacturers Locator Tool, retrieved from https://www.epa.gov/waterutilityresponse/chemical-suppliers-and-manufacturers-locator-tool

EPA, 2022b. *Understanding Water Treatment Chemical Supply Chains and the Risk of Disruptions*, retrieved from https://www.epa.gov/waterutilityresponse/water-sector-supply-chain-resilience

Federal Trade Commission (FTC), 2013. Federal Trade Commission: Decisions, Findings, Opinions, and Orders. Volume 155, retrieved from https://www.ftc.gov/system/files/documents/commission_decision_volumes/volume-155/decvol155.pdf

National Center for Biotechnology Information (NCBI), 2020. PubChem Compound Summary for CID 23665760, Sodium Hypochlorite, retrieved from https://pubchem.ncbi.nlm.nih.gov/compound/Sodium-hypochlorite

NSF International, 2021. Search for NSF Certified Drinking Water Treatment Chemicals, retrieved from https://info.nsf.org/Certified/PwsChemicals/

Odyssey Manufacturing, 2022. UltraChlor™: Exceptional Quality, retrieved from https://www.odysseymanufacturing.com/ultrachlor-bleach

Olin Corporation, 2019. *Sodium Hypochlorite Product Stewardship Manual*, retrieved from https://olinchloralkali.com/wp-content/uploads/2016/11/102-00553-0619_Olin-Sodium-Hypochlorite-Manual.pdf

Powder & Bulk Solids, 2021. "Olin to Cut Chlor Alkali Capacity at Alabama Plant," *Powder & Bulk Solids*, March 16, 2021, retrieved from https://www.powderbulksolids.com/chemical/olin-cut-chlor-alkali-capacity-alabama-plant

Prohaska, T., 2021. "Occidental Chemical to close Niagara Falls plant; 130 jobs lost." *The Buffalo News*, August 19, 2021, retrieved from https://buffalonews.com/business/local/occidental-chemical-to-close-niagara-falls-plant-130-jobs-lost/article_ddb5463c-010a-11ec-a536-9b2a8e99ba71.html

PSI Water Technologies, 2020. City of Springfield, Missouri, Upgrades Disinfection System from Gas Chlorine to On-Site Sodium Hypochlorite Generation, retrieved from https://4psi.net/case-study-springfield-mo.php#:~:text=On%2Dsite%20generation%20applies%20electricity,water%20to%20produce%20sodium%20hypochlorite.&text=A%20current%20is%20passed%20through,moving%20through%20the%20treatment%20process

The Chlorine Institute, 2017. *Pamphlet 96, Sodium Hypochlorite Manual, 5th Edition*. The Chlorine Institute.

The Chlorine Institute, 2020. *Pamphlet 10: North American Chlor-Alkali Industry Plants and Production Data Report, Edition 2019*.

The Chlorine Institute, 2021. *U.S. Chlorine/Sodium Hydroxide Production and Shipment Report,* September 2021.

U.S. International Trade Commission (USITC), 2021. USITC DataWeb, retrieved from https://dataweb.usitc.gov/

U.S. International Trade Commission (USITC), 2022. Harmonized Tariff Schedule (HTS) Search, retrieved from https://hts.usitc.gov/

World Integrated Trade Solutions (WITS), 2022. Trade Statistics by Product (HS 6-digit), retrieved from https://wits.worldbank.org/trade/country-byhs6product.aspx?lang=en#void