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RESEARCH BRIEF

Clean Wisconsin Environmental Health Initiative

Wisconsin Community Water Systems: Drinking Water Violations

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SUMMARY –

Everyone deserves clean, safe drinking water. In Wisconsin, about two-thirds of people get their drinking water from public water systems. Here we explore health-based violations in public water systems to better understand how common health-based violations are at public water systems in Wisconsin, which contaminants have been found at unsafe levels, and what violations are most common.

Key takeaways include:

- The vast majority of community water systems in the state have not had any health-based drinking water violations since 2015.
    - 23% of active community water systems have had a health-based drinking water violation since 2015.
    - These systems serve 807,000 residents, about 15% of the state's population.
    - 7% of community water systems have had a maximum contaminant level violation (MCL), meaning that contaminant concentrations in the drinking water exceeded health-based standards.
    - 18% of community water systems have had a treatment technique violation, meaning that the safety of the drinking water could not be ensured.
- MCL violations were most common for radionuclides, nitrates, arsenic, and disinfection byproducts.
- Systems in rural, lower-income areas of the state are more likely to have drinking water violations.
- 37% of rural, low-income systems had health-based violations compared to 20-23% of other systems.
- Rural, low-income systems had 0.85 violations per system compared to 0.23-0.46 for other systems.
- Health-based violations tended to be lower in systems serving higher percentages of non-white residents.
- This highlights the opportunity for targeted interventions to support rural, low-income systems to significantly improve overall water quality and health equity in the state.

Definitions

- **Community Water System:** a public water system that supplies water to the same population year-round.[1]
- **Maximum Contaminant Levels (MCLs):** specify the highest allowable contaminant concentrations in drinking water.
- **Maximum Residual Disinfectant Levels (MRDLs):** specify the highest concentrations of disinfectants allowed in drinking water.
- **Treatment Technique Requirements:** specify certain processes intended to reduce the level of a contaminant.
- **Health-Based Violation:** violation that falls into three categories: 1) exceeds the maximum contaminant level, 2) exceeds the maximum residual disinfectant levels, and 3) treatment technique requirements.[2]

Contents

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[1] Environmental Protection Agency (EPA). 2024. Information about public water systems. EPA. Information about Public Water Systems | US EPA
[2] Environmental Protection Agency (EPA). 2024. Safe drinking water act (SDWA) resources and FAQs. Enforcement and Compliance History Online. https://echo.epa.gov/help/sdwa-faqs#

Introduction

Access to safe, clean drinking water is a fundamental public health need. The U.S. Safe Drinking Water Act (SDWA) passed in 1974 establishes minimum safety standards for public water suppliers. SDWA has generally been a success, improving the drinking water quality for millions of Americans getting their drinking water from public systems.[3] Despite these improvements, violations of health-based water quality regulations still occur. Previous studies explored the spatial and temporal patterns of drinking water violations across the county, with a focus on the social and environmental justice implications of these violations.

Nationally, approximately 10% of all community water systems experience violations of health-based standards annually, with some systems facing repeat violations over multiple years.[4] Smaller, rural water systems are disproportionately affected, accounting for a higher percentage of violations compared to larger, urban systems.

Communities with higher proportions of low-income residents are more likely to be served by systems with health-based SDWA violation.[5] Evidence of racial disparities in exposure to unsafe drinking water has been reported, with systems serving low-income Hispanic populations in particular having more health-based violations or higher concentrations of contaminants of concern.[6]

Here we look at community water systems in Wisconsin with health-based violations to look at how frequent health-based violations are, where violations are occurring, and what contaminants are implicated in the violations.

Methods

We collected health-based violations at active community water systems that began in 2015 or later from the Wisconsin Department of Natural Resources' Drinking Water System Portal.[7] Community water systems are water systems that serve residences. Municipal community water systems are owned by cities, villages, or sanitary districts, while other-than-community systems are privately-owned (mobile home parks, apartment buildings, condominiums, etc.). Health-based violations include concentrations of contaminants in the drinking water above the maximum contaminant level (MCL), the health-based drinking water standard, or treatment technique violations. Treatment technique violations indicate that acceptable water quality cannot be assured.

Community water systems were classified based on EPA categorization: very small (<500 people); small (501-3,300); medium (3,301-10,000); large (10,001-100,000); and very large (>100,000).

To our knowledge, the exact boundaries of community water system service areas are not available, so demographics of population served were assigned to each system based on the county the water system is located in, following Allaire et al. County household income and percent non-white

[3] Sowby et al. 2023. The Safe Drinking Water Act at 50: A Policy Model for Grand Challenges. Water Resources Research 59: e2023WR035172; Weinmeyer et al. 2017. The Safe Drinking Water Act of 1974 and its role in providing access to safe drinking water in the United States. AMA Journal of Ethics 19: 018-1026.

[4] Allaire et al. 2018. National trends in drinking water quality violations, *Proc. Natl. Acad. Sci. U.S.A.* 115 (9) 2078-2083.

[5] Allaire et al. 2018.

[6] Schaider et al. 2017. Environmental justice and drinking water quality: are there socioeconomic disparities in nitrate levels in U.S. drinking water? Environ Health. 2019 Jan 17;18(1):3; Switzer D & Teodoro MP. 2017. The color of drinking water: class, race, ethnicity and Safe Drinking Water Act Compliance. Journal of the American Water Works Association 109:9.

[7] Wisconsin Department of Natural Resources (DNR). 2024. WI DNR. https://apps.dnr.wi.gov/dwsportalpub

population were obtained from the US Census Bureau's 2022 5-year community survey tables. Counties were classified as rural or urban based on the categorization in the Wisconsin Department of Health Services' Wisconsin Interactive Statistics on Health system. [8]

Following Allaire et al. rural counties were categorized as high-income or low-income. Counties with household incomes less than 85% of the state average were categorized as "low-income."

Results

Overall, 236 community water systems have had a health-based violation since 2015, affecting over 808,000 Wisconsin residents (Figure 1). This includes 28% of all municipal community systems and 15% of all other-than-municipal systems.

A total of 71 CWS had an MCL violation (8% of municipal systems; 5% of other-than-municipal systems) and 180 had a treatment technique violation (22% of municipal systems; 11% of other-than municipal systems).

The most common contaminant violations were for radionucleotides, arsenic, and disinfection by-products (Table 1). Note that 229 of the 385 municipal community system radionucleotide violations came from a single system. Treatment technique violations are summarized in Table 2. A summary of the health effects of the different contaminants is found in Table A1.

Rural low-income systems were more likely to have a health-based violation than rural-high income or urban systems (Table 3). There was little difference in the percent of systems with violations based on water system size. Systems serving higher percentages of non-white residents had fewer health-based violations (Table 3).

Table 1. Maximum contaminant level violations at municipal community water systems (MC) and other-than-municipal community water systems (OM) since 2015. See Table A1 for a summary of the health effects of these contaminants.

	Number of Systems		Number of total violations	
	MC (n=610)	OM (n=416)	MC	OM
Microbial Contaminants	**2**	**7**	**2**	**8**
E. coli bacteria	2	7	2	8
Inorganic Contaminants	**14**	**11**	**16**	**21**
arsenic	2	4	2	15
fluoride	3	0	5	0
nitrate	9	5	9	6
Radionuclides	**26**	**3**	**385**	**27**
Synthetic Organic Contaminants	**0**	**2**	**0**	**2**
di(2-ethylhexyl) phthalate	0	1	0	1
PFOA + PFOS Total	0	1	0	1
Volatile Organic Contaminants	**1**	**0**	**6**	**0**
benzene	1	0	6	0
Disinfection Byproducts	**8**	**0**	**25**	**0**

[8] Wisconsin Department of Health Services (DHS). WISH: Urban and rural counties. WI DHS. https://www.dhs.wisconsin.gov/wish/urban-rural.htm

Table 2. Treatment technique violations at municipal community water systems (MC) and other-than-municipal community water systems (OM) since 2015.

	Number of Systems		Number of total violations	
	MC (n=610)	OM (n=416)	MC	OM
Microbial Contaminants	**66**	**37**	**105**	**50**
Groundwater Rule	57	25	90	33
Revised Total Coliform Rule	12	13	15	17
Lead and Copper Rule	**39**	**8**	**68**	**15**
Disinfectants & Disinfection Byproducts	**56**	**6**	**74**	**7**

Table 3. Percent of active community water systems with health-based drinking water violations since 2015 and total violations per system, broke down by system characteristics. Note that one system's radium violations contributed a disproportionate number of total violations (nearly 30% of all violations; impacted numbers marked with an asterisk) so we also present violations per system excluding radium violations.

System Characteristic	Any health-based violation	MCL Violation	TT Violation	Violations per system	Violations per system, excl. radium
Urban	20%	7%	14%	0.89*	0.26
Rural High Income	23%	6%	19%	0.56	0.43
Rural Low Income	37%	9%	31%	1.04	0.85
Very Small	24%	6%	19%	0.49	0.43
Small	21%	6%	17%	0.42	0.35
Medium	26%	15%	14%	1.10	0.40
Large/Very Large	24%	11%	12%	3.57*	0.26
<10% Non-white	25%	7%	20%	0.49	0.46
10-20% Non-white	22%	7%	16%	1.21*	0.36
>20% Non-white	20%	6%	14%	0.33	0.29

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Average length of violations and number of systems with repeat violations are summarized in Table 4. MCL violations lengths varied by contaminant with bacterial contaminants having the shortest violation time. Radionuclide, arsenic and disinfection byproducts were the most likely to have repeat violations. Across all system types, 3% or fewer systems had repeat MCL violations and 6% or fewer systems had repeat treatment technique violations (Table 5). Rural systems, particularly low-income ones, were more likely to have repeat treatment technique violations.

Table 4. Length of health-based drinking water violations at community water systems and number of systems with repeat violations.

	Average (Min-Max) violation length in days	Any violation	Repeat violation	More than 3 violation years
Maximum Contaminant Level				
E. coli bacteria	13 (2-34)	9	1	0
Arsenic	429 (67-2,024)	6	3	0
Fluoride	229 (157-346)	3	1	0
Nitrate	703 (7-1,638)	14	1	0
Radionuclides	1,281 (7-3,319)	29	15	11
di(2-ethylhexyl) phthalate	523	1	0	0
PFOA + PFOS Total	190	1	0	0
Benzene	1,522 (1,368-1,680)	1	1	0
Disinfection Byproducts	353 (15-1,333)	8	3	2
Treatment Technique				
Disinfection Byproducts	48 (0-718)	62	15	3
Groundwater Rule	291 (1-2,421)	82	7	1
Lead and Copper Rule	137 (0-975)	47	18	9
Revised Total Coliform Rule	70 (1-431)	25	3	0

Table 5. Percent of community water systems with repeat health-based drinking water violations based on system size and locale. Repeat maximum contaminant level (MCL) violations are presented both including and excluding radium, which was by far the common repeat violation. TT refers to treatment technique violations.

	Repeat Violations			Three or more violations		
System Characteristic	MCL	MCL (excl. radium)	TT	MCL	MCL (excl. radium)	TT
Very Small	1.3%	1.1%	2.8%	0.2%	0.0%	1.3%
Small	0.7%	0.3%	2.7%	0.7%	0.3%	1.3%
Medium	3.2%	0.0%	3.2%	6.5%	1.1%	2.2%
Large	1.1%	1.1%	1.1%	4.5%	0.0%	0.0%
Very Large	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Rural Low Income	0.9%	0.9%	6.0%	2.6%	1.7%	3.4%
Rural High Income	1.1%	0.8%	4.3%	1.1%	0.0%	1.9%
Urban	1.3%	0.7%	0.7%	1.1%	0.0%	0.4%

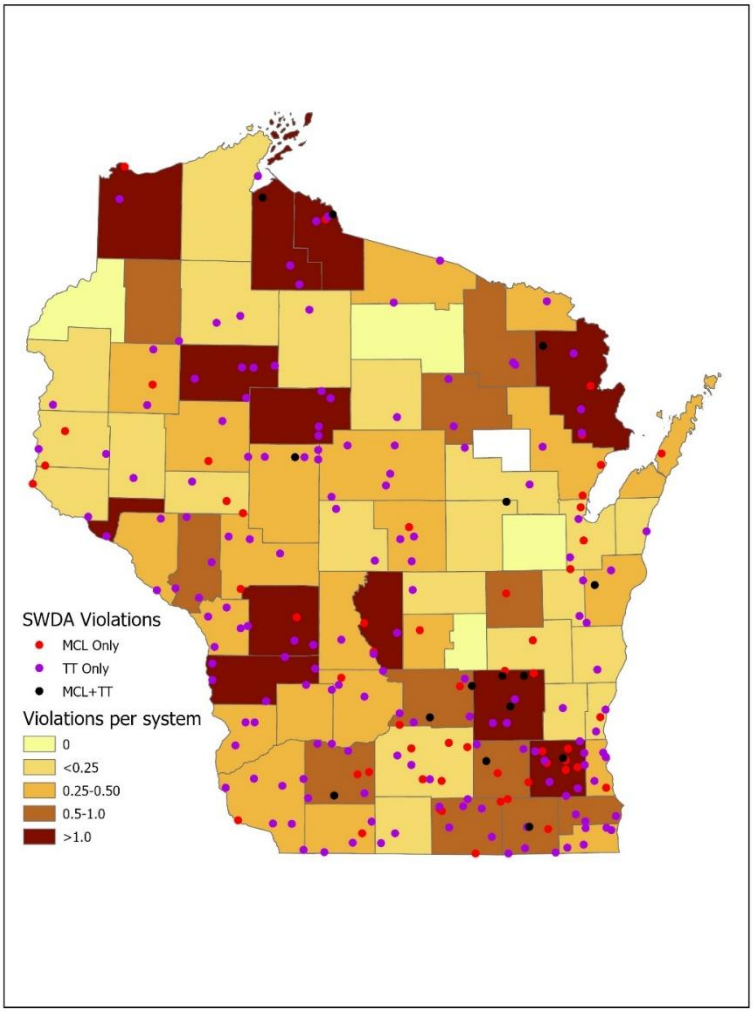

Figure 1a. Community water systems with health-based drinking water violations since 2015. Individual water systems with maximum contaminant level (MCL) violations and/or treatment technique (TT) violations are shown by the points. Counties are color-coded by the violations per systems located in the county.

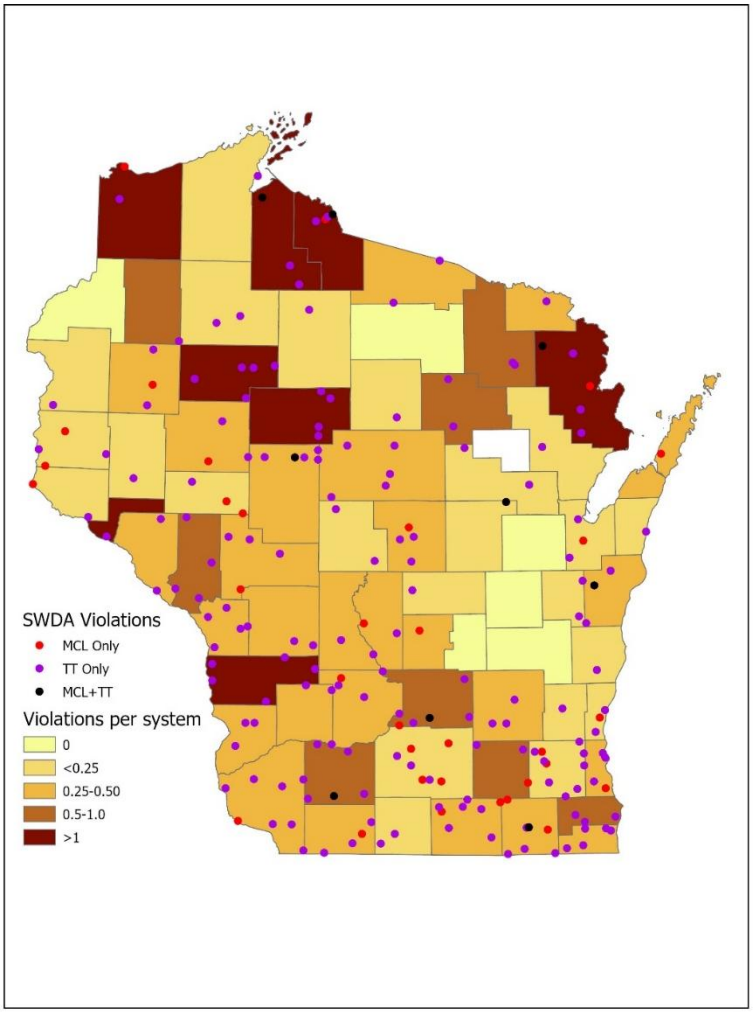

Figure 1b. Community water systems with health-based drinking water violations since 2015, excluding radionucleotide violations. Individual water systems with maximum contaminant level (MCL) violations and/or treatment technique (TT) violations are shown by the points. Counties are color-coded by the violations per systems located in the county.

Discussion

The vast majority of community water systems in Wisconsin are meeting water quality standards, with less than 10% of systems having a maximum contaminant level violation since 2015. More systems, but still a minority of systems, have had treatment technique violations.

However, the health-based violations that do occur impacted about 15% of the state's residents. Consistent with prior national analyses, these violations are more likely to occur at water systems in more rural and lower-income parts of the state. This

highlights the opportunity for targeted interventions to support rural, low-income systems to significantly improve overall water quality and health equity in the state.

Rural CWSs often face unique challenges in meeting health-based water quality standards. These unique challenges include limited financial resources and technical expertise, aging infrastructure, and population declines, which reduce the tax base available to support water system maintenance and upgrades.[9]

To address the unique challenges and systemic disparities that these areas face, various policy efforts should be considered. Previous research states that identifying hot spots and vulnerability factors associated with drinking water violations should be considered, rather than only focusing on systems that are underperforming. This allows for a more targeted approach that could better inform enforcement efforts. Prioritization of technical guidance and financial assistance is also needed to address the decline of technical expertise. For example, expanded training programs could help with operation issues and improve the most common violations. Other recommendations include creating attractive salaries that incentivize skilled workers to live and work in rural areas.[10]

To assist smaller water systems that face unique hardships, loosening restrictions on loans and outside financing should be considered. Additionally, when feasible, considering mergers and consolidations of systems may improve violation outcomes depending on existing infrastructure, liabilities, and distance between systems.[11]

Currently, the SDWA requires that all water systems share the same minimum water quality standards.[12] More research is needed to assess the effectiveness of these federal standards versus considering various water quality standards across states and municipalities. By allowing a variety in standards at the state level, this may increase efficiency and reflect local preferences and higher-priority contaminants.[13]

Other policy recommendations include improvement of data collection and monitoring practices of drinking water violations, as an estimated 26-38% of health-based violations in the United States are not reported or inaccurately reported.[14] Lastly, increased funding for technology developments and improved data management may also increase reporting efficiency.[15]

Ensuring that all Wisconsin residents have access to safe, clean drinking water requires commitment to equity and a tailored approach that considers the diverse needs of the state's communities. By addressing the systemic disparities in drinking water quality, Wisconsin can work towards more equitable public health outcomes and a stronger, more resilient water infrastructure system.

[9] Allaire et al. 2018.; Schaider et al. 2017.

[10] Allaire et al. 2018.

[11] Allaire et al. 2018.

[12] Environmental Protection Agency (EPA). 2024. National Primary Drinking Water Regulations. EPA. https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

[13] Allaire et al. 2018.

[14] Allaire et al. 2018.

[15] Allaire et al. 2018.

Limitations

This analysis is intended to be a high-level survey of drinking water violations in the state. Future more detailed analyses could particularly improve on the demographics of community water systems. County level demographics may not reflect the demographics at all individual systems within the county. This is particularly true for smaller systems and other-than-municipal systems. Assigning more precise demographic characteristics to each system would provide improved understanding of disparities in drinking water violations in the state.

Our dataset of violation only includes violations that have started since 2015. This is the extent of the publicly available drinking water violation reports on the Drinking Water System portal. There are likely some violations that have started prior to 2015 that are not included in this analysis. However, the number of such violations is likely small and is unlikely to affect the overall results.

Additional Resources

Clean Wisconsin: Clean Water, Clean Air, Clean Energy - Clean Wisconsin

WI DNR Drinking Water Systems Portal: Drinking Water System Portal: Home Page

WI DNR: Drinking Water

WI Interactive Statistics on Healthy System (WISH): WISH: Urban and Rural Counties | Wisconsin Department of Health Services

WI DNR 2023 Annual Drinking Water Report: 2023 Annual Drinking Water Compliance Report - Wisconsin Public Water Systems

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Appendix

Table A1. Public health concerns related to the contaminants found in Wisconsin Community Water Systems above health-based standards.

Total Coliform Bacteria	E. coli Bacteria	Arsenic	Fluoride	Nitrate
Coliform bacteria are "indicator organisms", indicating potential presence of disease-causing bacteria in water. Some types, like E. coli, can cause mild illnesses, while others may lead to more serious diseases. Common symptoms include flu-like symptoms such as fever, abdominal cramps, and diarrhea. Children and elderly members are more vulnerable to Coliform bacteria.[16]	E. coli Bacteria can cause diarrhea, urinary tract infections, pneumonia, sepsis, and other illnesses. Their presence in drinking water indicates contamination by human or animal waste. Children, the elderly, people with weaker immune systems, & international travelers are at higher risk of contracting an E. coli infection.[17]	Arsenic, a natural element found in soil and rock, can be transported to groundwater. Long-term exposure through drinking water and food can cause cancer and skin lesions, cardiovascular disease, diabetes, cognitive issues in children, and increased deaths in young adults.[18]	Fluoride, a mineral that prevents tooth decay, is found naturally in water or manually added through community water fluoridation. However, excessive consumption (beyond the recommended level) can be harmful, causing fluorosis (tooth discoloration) and has been linked to lower IQ in children.[19]	Exposure to high levels of nitrate can cause blue baby syndrome, increased risk of neural tube defects, increased risk of thyroid disease, and increased risk of colon cancer. Higher levels of nitrate are sometimes found in groundwater from waste and fertilizer use.[20]

Di(2-ethylhexyl) phthalate	PFOA + PFOS (PFAS)	Benzene	Disinfection Byproducts	Radionuclides
DEHP is a manufactured chemical added to plastics. Studies suggest that high DEHP exposure in pregnant women may cause preterm birth and delayed development in children. Only animals have been shown to develop liver cancer from DEHP exposure.[21]	PFAS are manufactured chemicals, and increased PFAS exposure is linked to a variety of health effects, including higher cholesterol, lower antibody response to some vaccines, liver enzyme changes, preeclampsia, pregnancy-induced hypertension, lower birthweight, and possibly kidney and testicular cancer. PFAS are found in consumer and industrial products and are now detected in groundwater and drinking water.[22]	Benzene is both a natural and manufactured chemical. It can get into drinking water supplies from industrial discharge and leaching from gas storage tanks and landfills. It is a carcinogen and can interfere with normal cell function leading to anemia and loss of white blood cells. Exposure to high levels can also impact central nervous system function.[23]	Disinfection Byproducts (DBPs) are chemicals made when chlorine or chloramine encounter water. Increased exposure to DBPs in drinking water has been associated with an increased risk of cancer, anemia, nervous system effects, and liver, kidney or central nervous system issues.[24]	Radionuclides occur in natural rock formations and are detected in drinking water. Long-term exposure to radionuclides has been associated with an increased risk for cancer and kidney toxicity.[25]

[16] PennState Extension. 2022. Coliform bacteria. PennState Extension. https://extension.psu.edu/coliform-bacteria

[17] Centers for Disease Control & Prevention (CDC). 2024. About Escherichia coli infection. CDC. https://www.cdc.gov/ecoli/about/index.html

[18] World Health Organization (WHO). 2022. Arsenic. WHO. https://www.who.int/news-room/fact-sheets/detail/arsenic

[19] Cleveland Clinic. 2023. Fluoride. https://my.clevelandclinic.org/health/treatments/11195-fluoride; National Toxicology Program (NTP). 2024. NTP monograph on the state of science concerning fluoride exposure and neurodevelopment and cognition: a systematic review. Research Triangle Park, NC: National Toxicology Program. NTP Monograph 08.

[20] WI DHS. 2025. Drinking water: nitrate. WI DHS. https://www.dhs.wisconsin.gov/water/nitrate.htm

[21] Agency for Toxic Substances and Disease Registry (ATSDR). 2022. ToxFAQs for Di(2-ethylhexyl) phthalate (DEHP). https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?

[22] ATSDR. 2024. How PFAS impacts your health. ATSDR. https://www.atsdr.cdc.gov/pfas/about/health-effects.html#:~:text.; WI DNR. 2024. Drinking water and groundwater program. DNR. 2023 Annual Drinking Water Compliance Report - Wisconsin Public Water Systems

[23] CDC. 2024. Benzene. CDC. Benzene | Chemical Emergencies | CDC

[24] Environmental Protection Agency (EPA). 2024. National Primary Drinking Water Regulations. EPA. https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

[25] WI DNR. 2024. Drinking water and groundwater program. DNR. 2023 Annual Drinking Water Compliance Report - Wisconsin Public Water Systems