

Citizen Groundwater Monitoring Program

Year 6 Report (2024)



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Introduction

Groundwater is the primary water source for municipalities, industries, and rural residents in St. Croix County, serving approximately 45,000 people through 17,000 private wells. While municipal water supplies undergo regular monitoring, private well owners bear the responsibility of managing the safety and quality of their own wells. To support private well owners in these efforts the Citizen Groundwater Monitoring Program (CGMP) was launched in 2019 to monitor and assess groundwater quality across the county.

The CGMP is a long-term groundwater study designed to identify trends in groundwater quality. During the first five years (2019–2023), the program analyzed water samples for various parameters, including nitrate-nitrogen, chloride, pH, alkalinity, total hardness, and conductivity. As the program entered its sixth year, it prioritized assessing long-term trends of just nitrate-nitrogen levels, since it is a health-related contaminant that is widespread in St. Croix County.

Nitrate-nitrogen is a persistent and pervasive contaminant in Wisconsin's groundwater. This compound, originating from fertilizers, manure, and organic material decomposition, is highly mobile and prone to leaching into groundwater supplies. Under natural landscapes such as forests and grasslands, nitrate-nitrogen concentrations in groundwater are typically low (less than 1 mg/L) due to the efficient uptake of nitrogen by plants. However, nitrate concentrations above 1 mg/L often indicate human activities influencing the landscape. Sources such as excessive fertilizer use on crops, improper manure management, bio-solids disposal, and septic systems contribute to nitrate contamination.

Since its inception, the CGMP has tracked nitrate-nitrogen concentrations in private wells across the county. Over six years, the program identified nitrate levels exceeding the drinking water standard (10 mg/L) in 12–13% of participating wells, while 77% of wells reported nitrate concentrations above 2 mg/L – a clear indication of impact of land-use practices on groundwater quality. Extending the 5-year study to continue nitrate-nitrogen monitoring allows for evaluation of long-term trends in groundwater quality across the county.

This Year 6 Report emphasizes the analysis of nitrate trends over time, identifying wells with increasing, stable, or decreasing nitrate levels. Among the 159 wells analyzed, 14.5% exhibited statistically significant trends, with 17 wells showing increasing nitrate levels, and 6 wells showing decreasing levels. These findings highlight the need for targeted outreach and land management practices to address nitrate contamination in vulnerable areas.

The CGMP provides valuable insights into groundwater trends and equips residents, policymakers, and resource managers with the data needed to protect this vital resource. The program's success relies on the willing participation of St. Croix County residents, whose contributions of well samples have been instrumental in establishing a robust baseline for groundwater quality trends.

Methods

The Citizen Groundwater Monitoring Program (CGMP) employs a systematic approach to evaluate long-term trends in groundwater quality across St. Croix County. To ensure consistent sampling and analysis, the following procedures were followed:

St. Croix County was divided into 2-mile by 2-mile grid cells, and one well from each grid cell was randomly selected for participation. This design ensures county-wide representation of private wells, capturing variability in land use, geology, and water quality. Landowner participation is voluntary, and participants selected are invited to contribute annual water samples for analysis.

During the designated sampling week, participants collected water samples from untreated spigots in their households (e.g., kitchen sink or outdoor spigot not connected to a water softener). Samples were collected into sterilized bottles provided by the county and returned to a central drop-off location. To maintain sample integrity, all returned samples were immediately refrigerated until transport to the laboratory. Water samples were analyzed for nitrate-nitrogen concentrations at the University of Wisconsin-Stevens Point's state-certified Water and Environmental Analysis Lab.

To assess trends in nitrate-nitrogen concentrations over the six-year study period, a Mann-Kendall trend test was performed for wells with at least five years of data. This non-parametric test is particularly suited for identifying monotonic trends in time-series data, such as groundwater quality. The null hypothesis assumes no trend in nitrate levels, while the alternative hypothesis indicates a statistically significant upward or downward trend. Tau values were calculated to determine the direction and strength of trends (if they are strong, moderate, or weak), with p-values below 0.05 considered statistically significant.

Results

Nitrate Concentrations

The average nitrate concentration in St. Croix County in 2024 was 5.48 mg/L and ranged from < 0.1 – 46.7 mg/L (Figure 1). These nitrate concentrations are representative of results from the previous five years. These concentrations reflect varying degrees of human impact across the region, with a substantial portion of wells exhibiting elevated nitrate levels. The following breakdown illustrates the distribution of nitrate concentrations among sampled wells:

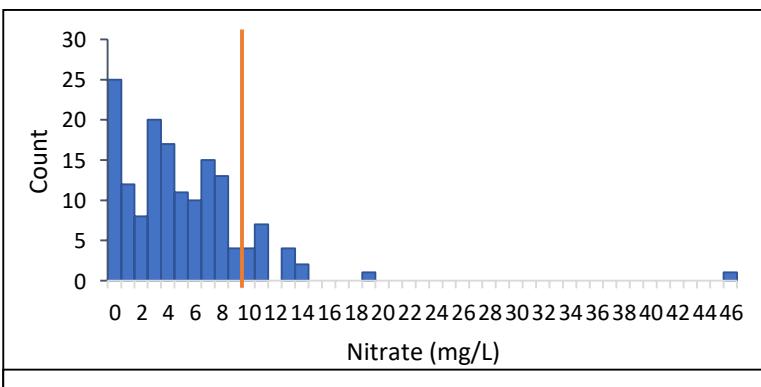


Figure 1. Distribution of the 2024 CGMP nitrate levels in water samples from St. Croix County. The vertical orange line represents the drinking water standard of 10.0 mg/L.

16% of wells had nitrate concentrations below 1 mg/L, indicating minimal human impact.

37% had concentrations between 1–5 mg/L, suggesting moderate human influence.

35% recorded levels between 5–9.99 mg/L, reflecting elevated inputs from human activities.

12% exceeded the 10 mg/L drinking water standard, indicating significant contamination.

Spatial Distribution

The spatial distribution of nitrate contamination has remained consistent since 2019, with elevated levels concentrated in central St. Croix County (Figure 2). This geographical pattern aligns with factors such as intense agricultural land use, shallow well depth, proximity to the water table, and the prevalence of the Prairie du Chien (limestone) aquifer. This aquifer is frequently tapped into by private drinking wells.

Nitrate Trends: 2019 - 2024

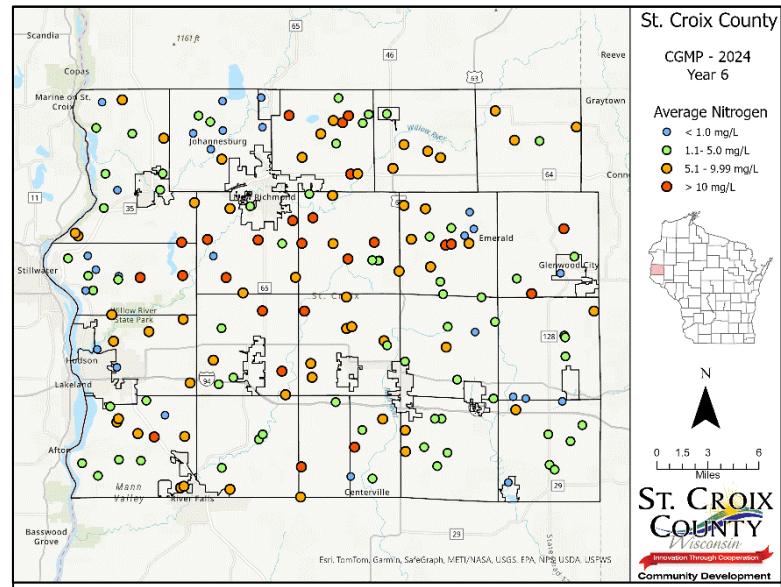


Figure 2. Map of average nitrogen concentrations (mg/L) from the Community Groundwater Monitoring Project (CGMP) between 2019-2024. The red points represent wells with concentrations greater than the drinking water standard.

There were 159 wells which had >5 years of data which was sufficient to test for trends. The Mann-Kendall test revealed that increasing nitrate concentrations were the most prominent trend in St. Croix County between 2019-2024 where 45% of wells tested showed a positive trend (Figure 3). More specifically:

- **Positive Trends (45%):** 34 wells (strong), 21 wells (moderate), 16 wells (weak) = 71 wells.
- **Negative Trends (28%):** 12 wells (strong), 14 wells (moderate), 18 wells (weak) = 44 wells.
- **No Change (16%):** 25 wells showed no detectable change in nitrate levels.
- **No trend (12%):** 19 wells showed no trend.

While trends were observed across the dataset, statistically significant changes ($p < 0.05$) were identified in just 23 wells (14.5%).

- **6 wells** had significant declines in nitrate with an average decreasing level of 3.0 mg/L (Figure 4). One of these declines was due to installation of a new well that resulted in -8.6 mg/L reduction in nitrate concentrations.

- **17 wells** had significant increases with an average increasing level of 1.3 mg/L (Figure 5).
- The remaining **124 wells (78%)** had no statistically significant trend.

These findings highlight considerable variability in nitrate trends across the study area. The prevalence of positive trends in certain wells underscores the potential influence of land use or management practices, while stable or declining trends in others point to localized improvements or natural attenuation processes.

Discussion

The CGMP provides a valuable dataset to better understand the groundwater quality and trends in St. Croix County. As the program continues to monitor nitrate concentrations, which remain a primary concern for public health, we can better understand the influence of land use, agricultural practices, and environmental factors on groundwater quality. This will allow resource managers to better identify areas most at risk, prioritize mitigation efforts, and implement targeted management and policy interventions to protect drinking water sources.

The average nitrate concentration of 5.48 mg/L in St. Croix County in 2024 falls below the 10 mg/L drinking water standard, yet it represents an ongoing concern, as nearly half of the wells tested

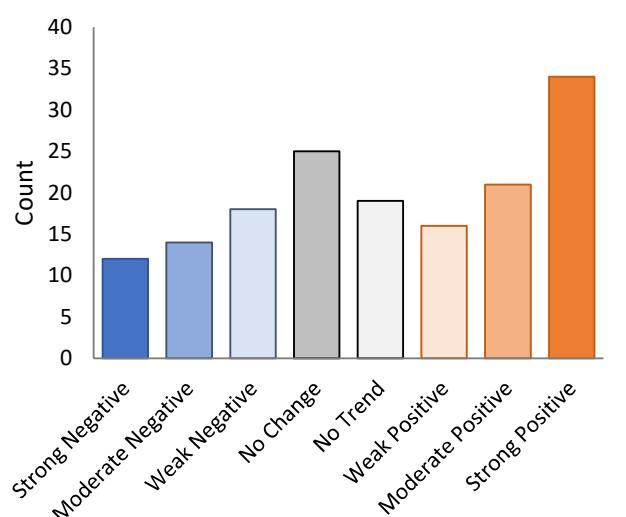


Figure 3. Distribution of trend direction and strength of nitrate concentrations from 2019-2024. These categories are determined based on Tau values from the Mann Kendall test of trend.

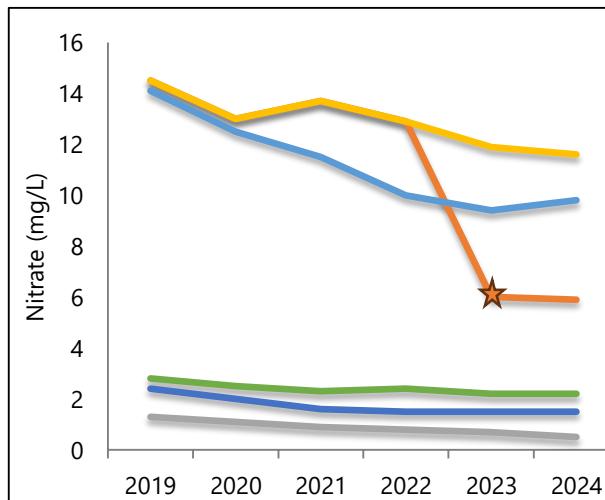


Figure 4. Nitrate levels from the six wells that showed a significant decrease between 2019-2024. Star indicates installation of a new well.

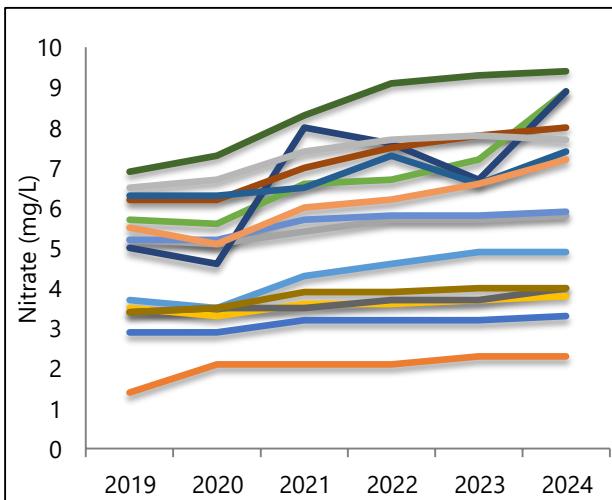


Figure 5. Nitrate levels from the 17 wells that showed a significant increase between 2019-2024.

(47%) reported concentrations above 5 mg/L. This level of contamination suggests significant influence from human activities, primarily agricultural practices, which are known to contribute to elevated nitrate levels. The fact that 12% of wells exceeded the 10 mg/L threshold is particularly alarming, as such concentrations pose a direct health risk, especially to vulnerable populations such as infants, where high nitrate levels can lead to methemoglobinemia (blue baby syndrome).

Spatially, nitrate contamination remains relatively concentrated in central region of St. Croix County, a pattern that correlates with areas of intensive agricultural land use. This finding aligns with known sources of nitrate pollution, including heavy use of fertilizers, and manure. In addition, the geology of St. Croix County is susceptible to fracturing and weathering, leading to solution cavities and conduits associated with karst aquifers, which makes it more vulnerable to nitrate contamination. This geology allows contaminants easy access to water supplies and underscores the importance of this monitoring effort.

Historically (1999-2005), nitrate data indicated that 10% of the wells in the County exceeded the drinking water standard. However, the percentage of wells exceeding the standard appears to be increasing. The CGMP found that approximately 12% of wells exceeded the standard of 10 mg/L. In addition, the analysis of nitrate trends over the six-year period revealed that most wells showed increasing nitrate levels. The prevalence of positive trends, particularly in agricultural regions, points to the continuing challenge of managing nitrate pollution in groundwater.

Identifying wells with decreasing nitrate levels provides valuable insights into how specific land management practices or environmental factors may contribute to localized improvements in groundwater quality. Among the 6 wells with significant declines in nitrate levels, 3 showed minimal reductions (<-1mg/L) while the remaining three exhibited more substantial decreases. Notably, the well with the largest decline (-8.6 mg/L) achieved this improvement through the installation of a new, deeper well, which reduced nitrate levels below the drinking water standard. The other two wells with declining trends may reflect the positive impact of improved agricultural practices, enhanced manure management, or natural attenuation processes, where contaminants are slowly filtered and degraded over time by the soil and groundwater system.

Trend data is increasingly meaningful with longer datasets. As the CGMP continues to collect annual data, the likelihood of observing more statistically significant trends will grow. Expanding the dataset and identifying additional wells exhibiting reductions in nitrate concentrations will enhance our ability to identify patterns and pinpoint the mechanisms driving successful improvements. Conversely, detecting more wells with significantly increasing nitrate levels will also provide crucial insights. Identifying these wells allows us to investigate potential sources of contamination, assess the effectiveness of existing mitigation efforts, and adjust our strategies accordingly. These findings can then inform targeted strategies to replicate effective practices across other areas of the county, while addressing areas of concern. This holistic approach aims to promote widespread groundwater quality improvements.

The findings from this study highlight the critical need for targeted outreach and intervention in areas with rising nitrate concentrations. The positive trends in nitrate levels emphasize the importance of continued research and monitoring, as well as the implementation of land management practices that reduce nitrate leaching into groundwater. Potential strategies to

address this issue include promoting the use of best management practices (BMPs) in agriculture, such as precision fertilization, buffer strips, and improved manure management. Additionally, the installation and maintenance of efficient septic systems, particularly in rural areas, should be emphasized to prevent further contamination.

Further research into the factors influencing nitrate trends, such as specific land use practices, well construction, and aquifer characteristics, will be essential to refining management strategies. Additionally, exploring new technologies and treatment methods for mitigating nitrate contamination, such as denitrification or the use of constructed wetlands, could provide valuable solutions for reducing nitrate levels in affected areas.

Conclusion

The Citizen Groundwater Monitoring Program (CGMP) has provided invaluable insights into the state of groundwater quality in St. Croix County, highlighting the persistent challenges posed by nitrate contamination. Over the six-year study period, the program has identified significant trends in nitrate concentrations, with a substantial proportion of wells exhibiting elevated levels, particularly in areas of intensive agricultural use. While some wells have shown improvements, the overall trend reveals an ongoing need for targeted action to address nitrate contamination, especially in areas with the most significant increases.

The continued presence of nitrate concentrations exceeding the drinking water standard of 10 mg/L in a subset of wells emphasizes the urgent need for proactive land management and policy interventions to protect public health. It is critical that the lessons learned from this study inform future groundwater management strategies, including the promotion of best management practices in agriculture, enhanced septic system maintenance, and continued public education on the importance of groundwater protection.

The CGMP's success is a direct result of the engagement of St. Croix County residents, whose contributions have enabled the program to establish a robust baseline for monitoring groundwater trends. As the program moves forward, it will remain a cornerstone of the county's efforts to safeguard its vital water resources. With continued support and participation, the CGMP can help ensure that St. Croix County's groundwater remains a reliable and safe source of drinking water for generations to come.

In closing, the findings of this report reinforce the critical importance of continued monitoring, research, and collaborative action to address nitrate contamination in the region. By working together, residents, policymakers, and resource managers can mitigate the impact of human activities on groundwater quality, ensuring the long-term sustainability of this vital resource. The CGMP stands as a model for how community-driven efforts can drive meaningful change in water quality management and safeguard the health of local ecosystems and residents alike.