

Source Investigation of Nitrate Contamination in Private Wells in Eau Claire County, WI

Dexter Zebro¹, Megan Ballweg¹, Danielle Bredehoeft¹, Jake Kentnich¹, Tori Vouk¹, Laura Suppes¹, Ted Johnson², Shane Sanderson², Audrey Boerner², Sarah Vitale³

¹Watershed Institute for Collaborative Environmental Studies – Environmental Public Health, ²Eau Claire City-County Health Department, ³University of Wisconsin Eau Claire – Geology

INTRODUCTION

- Nitrate is a naturally occurring compound found in groundwater, but also has anthropogenic sources
- Nitrogen-containing fertilizers, manure and septic tank effluent are potential sources of nitrate in private groundwater wells
- Private wells are not regulated
- WI bedrock aquifers are a mix of sand and gravel, allowing surficial contaminants (nitrate) to move through subsurface⁽¹⁾
- Nitrate levels in drinking water are hazardous when exceeding 10 mg/L⁽²⁾
- Infants and pregnant women are most at risk as high nitrate causes Blue Baby Syndrome and shortness of breath⁽³⁾
- This research focuses on patterns in data to determine sources of high nitrate in private wells in Eau Claire County, WI
- Indicator chemicals associated with agriculture and septic systems utilized to determine the potential source associated with high nitrate



Figure 1: Map of nitrate in drinking water in WI from Private Drinking Water Quality in Rural Wisconsin, Journal of Health, 2013.

OBJECTIVES

- Collect private well water samples that previously tested high for nitrate (5 mg/L or higher), focusing on indicator chemicals of agricultural and human wastewater (septic system) sources (Table 1)
- Share with home owners on site the research being conducted and the purpose of the indicator chemicals
- Gather and analyze data to determine trends of potential contamination sources in Eau Claire County
- Evaluate the practicality of using nitrate source investigation as a tool for preventing contamination and sharing information with the public
- Create necessary materials and methods to make this study reproducible by other health departments to continue research on high nitrate in private wells and possible future policy implementation

INDICATOR CHEMICALS

Table 1: Indicator chemicals, chemical purpose and limit of detection in this research

Agricultural Indicators		
Chemical Name	Chemical Purpose	Limit Of Detection (µg/L)
Atrazine	Herbicide	0.1
Desethylatrazine	Metabolite of Atrazine	0.2
Desisopropylatrazine	Metabolite of Atrazine	0.2
Alachlor	Herbicide	0.2
Metolachlor	Herbicide	0.2
Cyanazine	Pesticide (Restricted Use)	0.1
Acetochlor	Herbicide	0.2
Septic System Indicators		
Carbamazepine	Anti-convulsant	0.3
Caffeine	Stimulant	0.2
Carisoprodol	Muscle relaxant	0.3

METHODS

SITE SELECTION AND RECRUITMENT

- Collaborative research between UW – Eau Claire and Eau Claire City-County Health Department (ECCCHD)
- Institutional Review Board (IRB) approval sought and attained August, 2016
- Homes in Eau Claire County selected by previous nitrate tests over 5 mg/L (approximately 1,140 total sites) – Environmental Protection Agency drinking water standard is 10 mg/L
- Sites with nitrate over 5 mg/L divided by township and recruited via preliminary phone call and letter sent to well owner (Fig. 2)
- Interested homeowners contacted ECCCHD to schedule samples



Figure 2: Eau Claire County, WI and selected sampling townships

METHODS CONT.

WATER SAMPLING PROCESS

- Share research and indicator chemical purpose with home owners by issuing IRB approved consent form
- Samples collected in 1 L amber bottles from sample site before water treatment systems – typically outside or pressure tank taps
- Let water run for 2 minutes to flush pipes of potential debris and standing water
- Collect water sample
- Return samples to ECCCHD in cooler with cold packs



Figure 3: Inspecting a homeowner's well for potential disrepair that could lead to water contamination.

QUESTIONNAIRE

- Administered at home sample visits (Fig. 5)
- Used to gather information on well makeup, septic system, fertilizer usage, soil type, surface water sources, landfills, crops – proximity, application of fertilizers / pesticides, crop type and to map well proximity to other geographical features and potential source(s) of contamination (Fig. 4)



Figure 4: Map on questionnaire used to determine possible sources of contamination with source codes and distances

SAMPLE ANALYSIS

Samples analyzed at ECCCHD Public Health Lab

Nitrate

- Samples treated with interference suppressor
- Calibrate Ion Selective Electrode (ISE) with three known standards
- Concentration vs response plotted for calibration curve
- Sample response inserted into calibration curve gives sample concentration



Figure 5: Filling out a questionnaire with a homeowner during a sampling visit.

Herbicides, Caffeine & Pharmaceutical Products

- Analytes extracted from samples, blanks and control spikes with two solid phase extraction disks (SPE's)
- 1L sample drawn through SPE's, removed from disks with 4 mL ethyl acetate then 8 mL methylene chloride
- Extract concentrated to 5 mL final volume on hot plate
- Gas chromatograph with nitrogen-phosphorous detector calibrated with 3 known samples containing analytes of interest
- Concentration versus area counts are plotted to create calibration curve
- Blanks, samples and control spikes are injected
- Concentration obtained by inserting samples into calibration curve



Figure 6: Nitrate testing at ECCCHD via ion selective electrode (ISE)

STATISTICAL ANALYSIS

STATA software used for statistical testing

Pearson's correlation coefficient

- 0.1 < R < 0.3 = small correlation
- 0.3 < R < 0.5 = moderate correlation
- R > 0.5 = strong correlation

T-Test

- P-value ≤ 0.05 = statistically significant
- 95% confidence interval

PRELIMINARY RESULTS

Table 2: Participant response rates of townships sampled to date

Township	Response Rate	Township	Response Rate
Bridge Creek	12%	Otter Creek	0%
Brunswick	43%	Pleasant Valley	39%
Clear Creek	14%	Seymour	21%
Drammen	60%	Union	19%
Fall Creek	0%	Washington	39%
Lincoln	17%		
Ludington	17%	Total	27%

PRELIMINARY RESULTS CONT.

- 108 sites sampled and 97 samples analyzed as of April 20, 2018 (Table 2)
- All sites have an on-site septic system
- 24% (23/97) of samples nitrate level results were above the EPA's MCL of 10.0 mg/L
- 93% (90/97) are above the DNR's preventive action limit (PAL) of 2.0 mg/L
- 18% (17/97) of samples indicate < 1 µg/L of agricultural contaminants
- 6% (6/97) of samples indicate < 1 µg/L of human waste water indicators
- 3% (3/97) of samples contain indicators of both agricultural and waste water contamination
- Most common indicators found: (Fig. 7)
 - Desethyl Atrazine: (14/97)
 - Atrazine: (12/97)
 - Caffeine: (4/97)

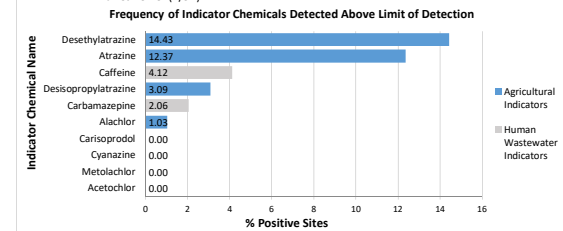


Figure 7: Frequency of indicator chemicals at sample sites

RESULTS/NEXT STEPS

Results:

- There is a moderate correlation between static water level and nitrate concentration (R=0.33, P-value=0.04)
- Agriculture is a source of nitrate contamination in private wells in Eau Claire County (P-value=0.0025)
 - Average nitrate concentration in wells with agricultural indicators present is 10.7 mg/L
 - Average nitrate concentration in wells without agricultural indicators present is 6.7 mg/L
- There is no correlation between:
 - Distance from well to septic system and nitrate concentration (P-value=0.12)
 - Well depth and nitrate concentration (P-value=0.11)

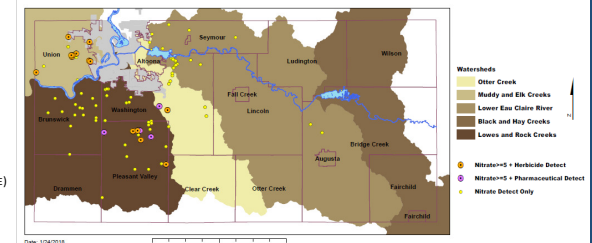


Figure 8: Map of herbicide, pharmaceutical and nitrate detected in Eau Claire County, WI watersheds

Next steps:

- Evaluate practicality of using nitrate source investigation as a tool for preventing contamination and sharing information with the public
- Create materials and methods to make this study reproducible by other health departments to continue research on high nitrate in private wells

REFERENCES

- Wisconsin Department of Natural Resources Bureau of Drinking Water and Ground Water. Nitrate and Drinking Water. Retrieved April 24, 2017 from <http://dnr.wis.gov/files/PDF/water/DWG00001.pdf>
- United States Environmental Protection Agency (2017). National Primary Drinking Water Regulations. Retrieved from <https://www.epa.gov/crground-water-and-drinking-water/national-primary-drinking-water-regulations>
- United States Environmental Health Protection Agency. (2017, March 10). The Effects: Human Health. Retrieved April 22, 2017, from <https://www.epa.gov/nutrientpollution/effects-human-health>

ACKNOWLEDGEMENTS

This research was funded by the Wisconsin Department of Natural Resources. A special thank you to all past UWEC Research Assistants and our study participants in Eau Claire County