

## Introduction

- Consumption of microbially contaminated well water is responsible for an estimated 78,000 annual cases of AGI in Canada<sup>1</sup>
- Private well water monitored by testing for total coliforms (TC) and *E. coli*<sup>2</sup>
- Differentiating between non-*E. coli* coliforms (NEC) and *E. coli* is essential<sup>3</sup>
- Groundwater contamination occurs via localized (source-specific) mechanisms or generalized (recharge-based) mechanisms<sup>4</sup>
- Microbial contamination concentrations (CFU/100 mL) and the relationship between NEC and *E. coli* are typically not examined

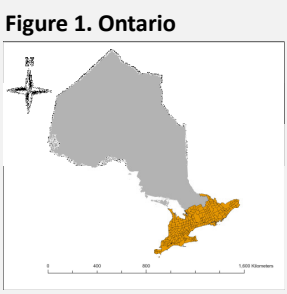
## Study Objectives

- 1) Identify biannual microbial hot and cold spots in Southern Ontario (2010 to 2021);
- 2) Develop cluster recurrence-based contamination indices (CIs); and
- 3) Compare CIs to mapped enteric infection rates and private well densities in Ontario

## Materials & Methods

### Ontario Microbial Water Quality Dataset (OMWQD)

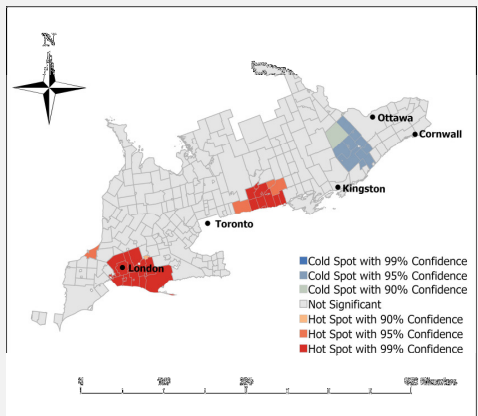
- 1,104,094 samples
- 292,638 wells
- 2010-2021
- NEC and *E. coli* CFU/100 mL
- Southern Ontario Census Subdivisions (CSD)



### Contamination Index (CI) development

- Getis-Ord Gi\* cluster overlapping
- *E. coli* and NEC concentrations
- NEC:*E. coli* concentration ratio
- Positive scores for biannual hot spot CSDs
- Negative scores for biannual cold spot CSDs

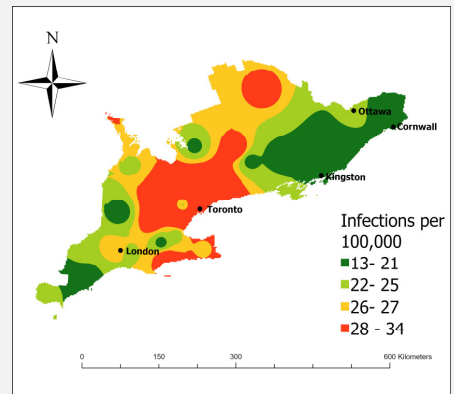
Figure 2. NEC concentration clusters, June 2014 to November 2014 (inclusive)



## Enteric infection rate mapping

- 2012-2021
- *Campylobacter*, *Cryptosporidium*, *Giardia*, and Verotoxigenic *E. coli* (VTEC)
- Age-adjusted (<5, 5-69, and >69)
- Inverse distance weighting interpolation

Figure 3. Older adult (>69) campylobacteriosis cases, separated into quartiles



## Well densities

- CSD wells/km<sup>2</sup> calculated via OMWQD
- Spearman's rho measures of association**
- CI vs infection rate
- CI vs well density
- Infection rate vs well density

## Results

Figure 4. *E. coli* index, 2010-2021

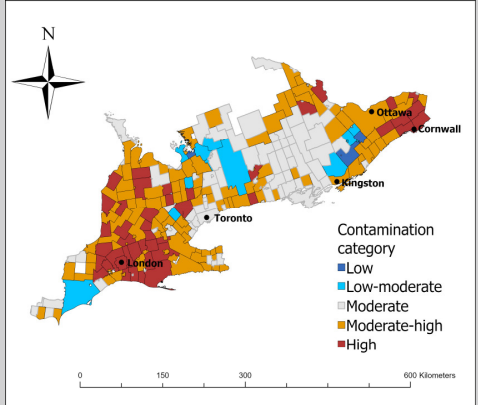


Figure 5. NEC index, 2010-2021

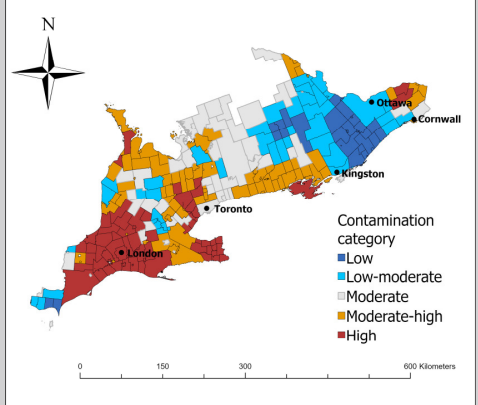


Figure 6. NEC:*E. coli* ratio index, 2010-2021

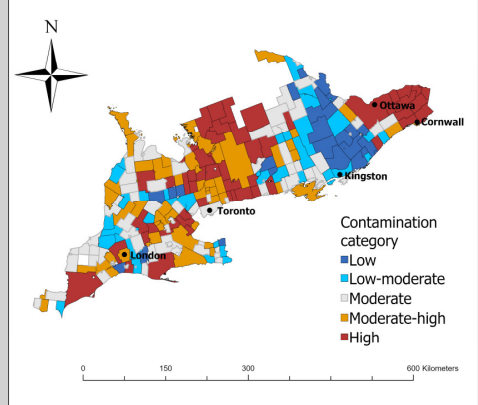


Table 1. Infection rate vs well density rhos

Pathogen	Age group		
	Under 5	5 to 69	Over 69
<i>Campylobacter</i>	-0.25**	0.05	0.1
<i>Cryptosporidium</i>	0.07	-0.14*	0.39**
<i>Giardia</i>	0.17*	0.22**	0.17*
VTEC	-0.07	-0.1	0.12*

\*p < 0.05, \*\*p < 0.001

Table 2. CI vs campylobacteriosis rhos

Index	Age group		
	Under 5	5 to 69	Over 69
<i>E. coli</i> index	0.40**	0.22**	0.06
Ratio index	0.01	0.12	0.26**

\*p < 0.05, \*\*p < 0.001

Table 3. CI vs VTEC enteritis rhos

Index	Age group		
	Under 5	5 to 69	Over 69
<i>E. coli</i> index	0.28**	0.38**	0.05
Ratio index	0.10	-0.13*	0.19*

\*p < 0.05, \*\*p < 0.001

Table 4. CI vs cryptosporidiosis rhos

Index	Age group		
	Under 5	5 to 69	Over 69
<i>E. coli</i> index	0.31**	0.28**	-0.27**
Ratio index	-0.04	-0.22**	0.20*

\*p < 0.05, \*\*p < 0.001

## Conclusions

- Evidence that a notable portion of *Campylobacter*, *Cryptosporidium*, and VTEC infections are associated with private well contamination
- Giardiasis is rarely due to the consumption of contaminated groundwater
- NEC:*E. coli* ratio CI correlations contrasted with *E. coli* CI correlations; ratio may supplement traditional *E. coli* testing by elucidating novel relationships
- CI highlights regions characterized by localized and generalized contamination mechanisms

## References

1) Majury A, Petculescu I, Hynds P, Brown R, McDermott K, Boudou M, Petculescu I, Hynds P, Brown R, McDermott K, Boudou M (2023) Estimating the burden of acute gastrointestinal illness due to *Giardia*, *Cryptosporidium*, *Campylobacter*, *E. coli* O157 and norovirus associated with private wells and residential systems in Ontario. *Environmental and Applied Water*, 10452, Article 7. <https://doi.org/10.1016/j.eawor.2023.104527>

2) <https://doi.org/10.1016/j.eawor.2023.104527>

3) <https://www.canada.ca/en/health-canada/services/environmental-and-climate/healthy-reports-publications/water-quality/index.html>

4) Petculescu I, Hynds P, Brown R, S, McDermott K, & Majury A (2022) An assessment of total coliforms and associated faecal coliforms in water quality indicators from large Ontario private drinking water well datasets. *Science of the Total Environment*, 848, 157478. <https://doi.org/10.1016/j.scitotenv.2022.157478>

5) Hynds P, Petculescu I, S, G, S, L, W, & Majury A (2024) Groundwater source contamination mechanisms: Physicochemical profile clustering, risk factor analysis and multivariate modelling. *Journal of Contaminant Hydrology*, 259, 47-56. <https://doi.org/10.1016/j.jchhyd.2024.105202>