Sources of drinking water contamination for the M’Chigeeng First Nation in West Bay, Manitoulin Island

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Assessing sources of contamination impacting drinking water for the M’Chigeeng First Nation in West Bay, Manitoulin Island, Lake Huron, ON:

• Monitoring for chemical tracers of wastewater contamination in West Bay
• Analysis of data on fecal coliform bacteria in raw drinking water for temporal trends related to meteorological conditions
Study Area

Gore Bay
Meteorological Stn

West Bay
M’Chigeeng FN
Introduction

The impact of land based activities on local drinking water intakes needs to be thoroughly investigated to help establish Intake Protection Zones (IPZs) for Source Water protection (SWP) planning --- little research exists.

Threats to sources of drinking water require identification and quantification to help guide municipal decisions for infrastructure investment and regulatory changes to protect the quality of drinking water.
Research Hypotheses

Contamination of raw drinking water for the M’Chigeeng in West Bay, Manitoulin Island:

Hypothesis 1: Is not correlated with continuous discharge from the wastewater lagoon

Hypothesis 2: Is not correlated with meteorological events (e.g. precipitation, wind speed and direction, snow melt) that drive land-based runoff and/or groundwater flow.
Approach

• Analyze the temporal data on waterborne pathogens (provided by Health Canada) in raw water at the M’Chigeeng drinking water intake in West Bay, Manitoulin Island

• Test for statistically significant correlations between waterborne pathogens and the following parameters:
  o Lagoon discharges
  o MET data
  o Land use
  o Currents

• Evaluate whether wastewater (e.g. lagoon, septic) is the source of contamination in the drinking water by monitoring for chemical tracers of wastewater contamination
  • Artificial sweetener (i.e. Sucralose)
  • Caffeine
Relevance/Significance

The data will be useful for developing a source water protection plan for the M’Chigeeng First Nation
First research characterizing contamination in the Georgian Bay area of Lake Huron.
The thermocline can be investigated as a “protection” strategy for Source Water Protection in the summer months during lake stratification

Partner Organizations:
Ontario First Nations Technical Services Corporation (Stephanie Allen)
Institute for Watershed Science, Trent University
United Chiefs & Councils of M’nidoo M’nising Technical Services
Public Health Office of Ontario, Kingston (Anna Majury)
Data to be presented:

Preliminary compilation and synthesis of data generated by Health Canada on fecal bacterial counts at the West Bay drinking water intake for the M'Chigeeng First Nation.

Information on meteorological data accessed to determine whether there are associations between weather patterns (e.g. rain, wind) and bacterial contamination at the drinking water intake.

Data generated in collaboration with Dr. Anna Majury, Ontario Public Health Office (Kingston) on molecular analysis of E. coli bacteria in water samples collected at the drinking water intake.

Monitoring data for sucralose and caffeine at the wastewater discharge and drinking water intake for the M’Chigeeng FN in West Bay
Passive Samplers for Monitoring Tracers of Wastewater Contamination in Surface Water

**Passive sampling**
- Determines time-weighted average concentrations over the period of deployment (2-4 weeks)
- Analytes are concentrated and stable when retained by the collection medium

**Sucralose artificial sweetener:**
- Ubiquitous in wastewater
- Persistent
- Recognized tracer of wastewater contamination

![Sucralose](image)

**Caffeine:**
- Ubiquitous in wastewater
- Less persistent

In West Bay in Sept. 2014, the depth of the thermocline was 13.7 m.
- Epilimnion: 16 – 17 °C
- Hypolimnion: 14 °C

“Polar Organic Chemical Integrative Sampler” (POCIS)
Lagoon discharge

Drinking water intake

Wastewater pumping station

GIS map developed by Chad Cordes
M’Chigeeng Drinking Water Intake
M’Chigeeng Wastewater Discharge
Assumptions

Assume little time lag between the meteorological and other parameters and the coliform data for raw drinking water
Assume no contaminants are coming at a distance via Lake Huron
Assume our monitoring results from the 4 to 6 week summer sampling window is representative of conditions throughout the year
Gore Bay MET data and wind patterns are comparable to West Bay (which has no Met Data)
Assumptions
Preliminary compilation and synthesis of data provided from Health Canada on fecal bacterial counts at the West Bay drinking water intake

Data from 2004 to 2014

No exceedances for all parameters tested (about 175)

Background Bacteria were almost always detected and are not suitable for looking for patterns (CFU/100mls almost always over 200)  
E. coli were almost always not present and these data are not suitable for looking for patterns (CFU/100mls almost always 0)

Total Coliform data were discontinued and restarted in 2011 (4 years of data) but these data are suitable for looking for patterns
Preliminary compilation and synthesis of data provided from Health Canada on fecal bacterial counts at the West Bay drinking water intake

For Total Coliforms, determined trends for:
- Precipitation on the day of and the day after intake sampling
- Wind direction (degrees) on the day of and the day before intake sampling
- Wind speed on the day of and the day before intake sampling
- Monthly trends
Information on meteorological data bases accessed to determine whether there are associations between precipitation and bacterial contamination at the drinking water intake.
2) Information on meteorological data bases accessed to determine whether there are associations between precipitation and bacterial contamination at the drinking water intake.

\[ y = 0.0197x + 2.0362 \]

\[ R^2 = 0.0165 \]
3) Information on meteorological data bases accessed to determine whether there are associations between wind direction and bacterial contamination at the drinking water intake.

\[ y = -0.0182x + 22.449 \]

\[ R^2 = 0.0035 \]
Information on meteorological data bases accessed to determine whether there are associations between wind direction and bacterial contamination at the drinking water intake.

\[ y = -0.0254x + 22.109 \]

\[ R^2 = 0.0075 \]
http://www.windfinder.com/windstatistics/gore_bay_manitoulin_isle
(5) Information on meteorological data bases accessed to determine whether there are associations between wind speed and bacterial contamination at the drinking water intake.

\[ y = 0.0014x + 44.928 \]

\[ R^2 = 1E-05 \]
Information on meteorological data bases accessed to determine whether there are associations between wind speed and bacterial contamination at the drinking water intake.

\[ y = -0.0243x + 46.062 \]

\[ R^2 = 0.0049 \]
3) Information on meteorological data bases accessed to determine whether there are associations between month of sampling and bacterial contamination at the drinking water intake.
Conclusions

No direct correlations between:
• Precipitation and Total Coliforms
• Wind direction and Total Coliforms
• Wind speed and Total Coliforms

There are no monthly or seasonal patterns for Total Coliforms

September bubble associated with Canada Geese migration?
The wastewater lagoons are “septicized” by overburden and rarely is *E. coli* are found in West

Background bacteria and total coliforms are naturally found in West Bay and are not associated with Land Use (no observable agriculture)
Data generated by the Ontario Public Health Office (Kingston) on molecular analysis of bacteria in water samples collected in West Bay

No *E. coli* were detected by molecular analysis in any of the water samples collected of West Bay taken at either the drinking water intake or the wastewater discharge stations

**COLLECTION DATE:** Wednesday, September 17, 2014

1.5 m
4.5m
12 m
21m
Results of the analysis of passive samplers deployed in West Bay, Manitoulin Island for indicators of wastewater contamination: SUCRALOSE

<table>
<thead>
<tr>
<th>STDEV at Intake, Discharge and Below Thermocline for Sucralose</th>
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<tr>
<td>1</td>
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<td>High</td>
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Results of the analysis of passive samplers deployed in West Bay, Manitoulin Island for indicators of wastewater contamination: CAFFEINE
Conclusions

The chemical tracers of wastewater contamination were detected above and below the thermocline at the wastewater discharge. Indicates that wastewater is impacting sources of drinking water intake.

Source could be:
- Wastewater lagoon entering via ground water bottom of West Bay
- Septic leakage

Higher concentrations (i.e. 2x) in the hypolimnion

Thermocline is a barrier to movement of wastewater, at least in the summer.
Summer Lake Stratification Zones

- Epilimnion
- Thermocline
- Hypolimnion
Where do I go from here?

Other analytes applied to POCIS extracts: Tamanna Sultana

Multivariate statistical analysis of MET data: Erica Nol as resource

Details on timings of direct wastewater discharge to West Bay as a result of broken sewage lift pump: Stephanie Allen


Continue sampling in 2015? Resampling in the Spring under mixed conditions with no thermocline present would further confirm thermocline as “barrier”
Spring Conditions of no Stratification:
Form concentrations of caffeine and sucralose at all depths confirm "barrier" action of thermocline in summer.
Writing of thesis, Winter 2015 semester

Introduction and literature review
Multivariate statistical analysis of data
Research on persistent wastewater products in our drinking water like caffeine and sucralose and their use as wastewater tracers
Research that explores the “impermeability” of a thermocline and if this phenomenon has been exploited as a drinking water protection strategy to date
Research that supports “septicizing” of wastewater lagoons through continuous discharge conditions
Research on the Great Lakes: 1) thermoclines, 2) groundwater movement
Finish Jan 30th, 2015
Discussion and conclusion/summary

Is it reasonable to suggest thermoclines can be used in the management and protection of Drinking Water Intakes by placing Intakes and Discharges on opposite sides of the thermoclines?

Contact engineering firms to determine why intakes and discharges are generally at the same depths, and what parameters are currently used to establish depths; consider Public Health Office drafting future guidelines.

Comparison of Lake Ontario data with Lake Huron: 1) thermoclines 2) groundwater movement

Is it reasonable to purposefully allow wastewater lagoons to continually overflow and “septicize” through an overburden and does this have advantages to current practices of discharging into surface water?

Finish March 30th, 2015
Revisions

Complete thesis by April, 2015

Defend in summer semester; May to August, 2015

Complete by Aug 31, 2015
Other considerations

Complete half course in Winter Semester

Other thoughts or suggestions from the committee?

CONTRIBUTION TO SOURCE WATER PROTECTION PLAN FOR FN:
Presently the continuous discharging wastewater lagoon is best (i.e. fixing the discharge pipe is not recommended)

Wastewater contaminants like Personal Care Products (estrogen, anti-depressants) are impacting the M’Chigeeng drinking water intake. Consider ozonation drinking water purification in the future.