Urban pollution footprints on the Great Lakes

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Urbanization of Great Lakes watersheds stresses our water resources

Pathogens carried by fecal pollution in surface waters

Sources: Agricultural runoff*  
Sewage discharges*  
Urban stormwater

Map: University of Michigan Water Center

Agricultural runoff also a major stressor
How do watershed managers find a needle in a haystack?

- Up to 30% of wastewater is “lost” in the system (USGS)
- Major metropolitan area: 3,000 miles of city owned and 3,000 miles of home laterals
Project Overview

Lake wide       Nearshore by beaches       City block

• How much sewage is released from watersheds? *(Compare this to agriculture, compare across urban areas)*

• How is sewage distributed to nearby beaches? *(Milwaukee as a case study)*

• How can we locate the physical breeches in the system? *(create a optical sensor, deploy in two test areas, Milwaukee and Clinton)*
Objective 1: Quantify fecal pollution amounts and sources from eight watersheds across a gradient of agricultural to urbanized land use.
Heat map comparing concentrations of fecal indicators in river sites. (Compare columns, not rows)
Heat map comparing concentrations of fecal indicators in river sites. (Compare columns, not rows)
Yields: What watersheds add the most human fecal pollution per acreage?

Optical sensor work focused on the two worst

Human Lachnospiraceae: Average Event Yield (CN/km²)
- 3.57E+10 - 1.80E+12
- 5.70E+12 - 8.06E+12
- 9.60E+12 - 1.12E+13
Yields: What watersheds add the most ruminant fecal pollution per acreage?
Objective 1: Quantify fecal pollution amounts and sources from six watersheds across agricultural to urbanized land use

**Stakeholders:** Watershed managers
- Initial: TMDL team (occurring now)
- Future: Clinton River Watershed (with USGS)

**How information will be used:**
Prioritize management to reduce sources. i.e. **TMDLs, permitting** - *work directly with TMDL team*

**Policy Brief Key Message:** High fecal coliforms are from human and non-human sources. Human sources are the greats health risk
Objective 2) Integrate source specific loading into nearshore hydrodynamic modeling

Use existing nearshore Milwaukee Model with 16 events

Determine the degree in which beaches are impacted by sewage discharges

**Stakeholders:** beach managers

**Policy Brief Key Message:**
Beaches may need to be preemptively closed following major rain events under specific conditions
Objective 3) correlate optical properties with alternative indicators

Alternative bacterial indicators detected by qPCR are three orders of magnitude more sensitive than optical signals

Stakeholders: municipalities

Policy Brief Key Message: Rapid sensor technology is needed to effectively direct fiscal resource to address widespread problem
Stakeholders engagement

- Workshop with stakeholders (conceptual model) - near completion
- Beach manager surveys (has shaped dissemination)
- Policy briefs and technical reports (translational aspect of publications)
- Directly working with the TMDL team (iterative input during TMDL implementation, longstanding collaboration leads to opportunities)
Source Specific Fecal Indicators Emphasize Human Health Risk for Water Quality Monitoring

**Key Message**
High concentrations of fecal coliforms from human and non-human sources are a frequent and costly impairment of water quality. Human sources carry the greatest health risk and should be minimized.

**What is the Issue?**
Elevated counts of fecal indicator bacteria, including fecal coliforms, are used to warn of possible pathogens in recreational waters, and pathogens are the most frequent water quality impairments in the United States (EPA, 2014). Advisories and beach closures are regularly implemented to minimize recreational exposure to impacted waters and reduce disease outcomes. There are many sources of fecal coliforms, both human and non-human, but human fecal pollution has well documented association with illness following recreational exposure to sewage-contaminated water (EPA, 2010). Traditional water quality monitoring does not discern the source of fecal pollution, and reliance solely on fecal coliform monitoring may misdirect cleanup efforts by focusing on sources that are not associated with the pathogen impairment.

**The Context**
Fecal indicator bacteria used for water quality monitoring are common to human, non-human and environmental sources (ref). Generally fecal indicator bacteria do not cause disease but they are easy to measure in water samples and elevated counts may indicate a human sewage pollution source. When the source of pollution in recreational waters is human sewage there is an increased risk for exposure to human pathogens and the association between sewage pollution and gastrointestinal illness is well documented (ref). However, frequently the source of fecal coliforms and other fecal indicator bacteria is not human sewage and health risks associated with exposure can be much lower (Soller et al., 2010).

**What is the Science Gap?**
Hot spots for fecal pollution are not always hot spots for human sewage (Figure 1).

**Policy Recommendation**
Prioritize reducing human sources for the maximum human health benefit.
Policy briefs

Key message

Graphic

Science gap

Policy Recommendation

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**Policy Recommendation**

Prioritize reducing human sources for the maximum human health benefit.
Project Expertise

**Principal Investigator**
Sandra McLellan, Professor  
School of Freshwater Sciences  
University of Wisconsin-Milwaukee  
*Environmental Microbiology and Bacterial Genetics*: tracking fecal pollution sources in the environment using alternative indicators

**Co-Principal investigators**
Hector Bravo, Professor  
Department of Civil Eng. and Mechanics  
University of Wisconsin-Milwaukee  
*Modeling*: hydrodynamic model of nearshore to determine sewage distribution of beaches

Steve Corsi, Hydrologist  
United States Geological Survey  
Madison, Wisconsin  
*Hydrology*: calculating pollutant loads from eight watersheds (GLRI), innovative sampling and detection of pollutants

**Additional Team Members**
Jenny Kehl  
Director, Center for Water Policy  
School of Freshwater Sciences  
University of Wisconsin-Milwaukee  
*Water Policy*: communicating science for policy makers and stakeholders, creating policy briefs

Georgia Mavrommati  
Post Doctoral Researcher  
Water Sciences Center  
Michigan State University  
*Environmental Economics*: stakeholder engagement, socioeconomic and natural systems linked in a model (water quality/sewage case study)