Subsurface Transport of *Cryptosporidium* Oocysts in Soils of Wisconsin’s Carbonate Aquifer Region

Zach Zopp
Assistance Researcher: University of Wisconsin Madison
Dept. of Biological Systems Engineering (BSE)
Cryptosporidium parvum

- Cryptosporidium parvum (C. parvum) is a pathogenic protozoa parasite common to bovine manure

- Cryptosporidiossis
  - In humans

- Human contraction occurs via:
  - Drinking water, recreational water, or food
Reported Cryptosporidiosis Cases, Wisconsin, 2005-2013

1) Soil Treatment

2) Susceptibility

3) Dairy

HOW?
Project Impetus

• Area of Interest Northeastern Wisconsin

• Soil based manure treatments systems have vulnerabilities that may lead to the contamination of ground and drinking water supplies
Project Objectives

1. Determine if irradiated *C. parvum* is an effective surrogate for live *C. parvum* soil transport

2. Determine the transport potential of *C. parvum* for several NE WI soils

3. Relate transport potential to soil characteristics (texture, moisture, organic matter etc.)
Field Methodology

• Laboratory based study using intact 6 inch diameter x 20 inch tall undisturbed soil columns from NE WI

• Three soils selected for soil columns
  – Lomira (LvB), Hochheim (HmB), Kewaunee (KnB)
  – Silt Loam (LvB & HmB) and Silty Clay (KnB)
Field Methodology
Laboratory Methodology

• Simulated rainfall experiments on soil columns

• Surface inculcated with $10^6$ *C. parvum* via a diluted 1% manure

• Collection of leachate and depth wise distribution of soil for *C. parvum* analysis via EPA 1623.1
  – No EPA Soil Extraction Method
Cryptosporidium Soil Extraction Method

- 1623.1 Liquids 0 g Soil: 75.3%
- SPEG 0g Soil Dev.: 67.7%
- SPEG 5g Soil Dev.: 44.1%
- SPEG 5g soil Trial: 49.6%
- Kato Method 5 g Soil: 21.7%
- Peterson Method 5 g Soil: 8%

EPA Minimum Recovery 32%
Objective #1

• Are Irradiated *C. parvum* Oocysts an Effective Surrogate?

• Yes
  – Irradiated oocysts behave in a similar manor for both leachate and soil
Objective #2

• Transport Potential of Soils in NE WI
  – Treatment
    • Irradiated *C. parvum*
    • 3 Soil Series (LvB, HmB, KnB)

  – Simulation Conditions
    • Initial Saturated Soil Condition
    • Duration of One Pore Volume
    • Rainfall rate individualized to maximal flux without ponding
    • Bromide Tracer
Mean Flux 2.4 cm hr$^{-1}$
Objective #2

• Lomira (LvB) & Hochheim (HmB) Silt Loam
  – Potential for Transport to Groundwater
    • Rapid Migration
    • Breakthrough
    • First Flush

• Kewaunee (KnB) Silty Clay
  – Potential for Transport to Surfacewater
    • Ponding
    • Soil Retention
Objective #3

• Soil Characteristics (Stimulate)
  – Texture
    • Silt Loams have higher leachate C. parvum concentrations and dominate “First Flush Effect”
  – Hydraulic Conductivity
    • Quantify impact of Macropores, but inherit to texture
  – Macropores
    • The presence of connective macropores observed to increase magnitude of First Flush Effect (LvB)
Objective #3

• Soil Characteristics *(Inhibit)*
  – Texture
    • Silt Clay
      – May prevent breakthrough
      – Delay “First Flush Effect”
    • Percentage of Clay in B Horizon
      – Clay texture (50%)

  – Moisture Content
    • Expansion of Silt Clay and Clay texture
Summary

• $S^3$PEG method produced repeatable soil extraction recoveries of *C. parvum* above EPA 1623.1 minimum recovery standards

• Irradiated *C. parvum* is a viable surrogate for the transport of live *C. parvum* Oocysts in soil

• Under plausible conditions, the Silt Loams of NE Wisconsin have the potential to transport *C. parvum* to groundwater
Impacts

• Expands knowledge base of In-situ based *C. parvum* research

Peng, 2011

Harter, 2000
Collaborators & Partners

• Dr. Sharon Long: Professor, UW-Madison Dept. of Soils
• Dr. Anita Thompson: Associate Professor, UW-Madison Dept. of BSE
• Dr. K.G. Karthikeyan: Professor, UW-Madison Dept. BSE
• Dr. Fred Madison: Emeritus Professor, UW-Madison Dept. of Soils
• WSLH Staff (J. Olstadt, B. Hoffman, M. Collins, J. Allan)
• WI Department of Natural Resources
• WI Groundwater Coordinating Council
References


Questions?

• What about radish macropores?