Surface Runoff from Manured Cropping Systems Assessed by the Paired-Watershed Method, Part 2: Pathogen Transport

Mark Borchardt,
Susan Spencer and Bill Jokela
USDA-Agricultural Research Service
US Geological Survey Wisconsin Water Science Center
Marshfield, Wisconsin USA
Manure’s Double-Edged Sword

Manure as Asset

Manure field-application is a cost-effective and sustainable approach for optimal soil tilth and fertility.

Manure as Liability

Manure may contain pathogens harmful to both humans and livestock.

Societal goal: Maximize the beneficial uses of manure while minimizing environmental pathogen transmission.
Human and Livestock Pathogen Movement in the Environment

- Wildlife
- Livestock
- Manure
- Manure
- Birds
- Recreational water
- Drinking water
- Wastewater
- Hospitals
- Communities
- Ill individuals
- Contaminated meat
- Drainage tiles and ditches
- Manure application
- Runoff
- Water treatment plant
- Wastewater treatment plant
- Drinking water
- Contaminated produce
- Wildlife
- Vectors
- Contaminated groundwater
- Airborne pathogens
- Livestock
- Livestock contact
- Contaminated meat
- Scavengers
- Farm workers
- Slaughterers
- Manure
- Animal feed
- Rogers and Haines, 2005, EPA/600/R-06/021
Study Objectives

1. Quantify bovine pathogens in runoff from manure-applied fields
2. Identify cropping, tillage, and manure application practices that minimize pathogen runoff
Field Site

- UW/USDA-ARS Research Station, Marshfield, WI.
- Withee silt loam, 1-3% slope
- Surface drainage using drive-through diversion pathways and berms
- Each field about 4 acres, cropped in corn
- Manure application once per year, about 5,800 gals/acre
Runoff Monitoring Stations

H-flume: stage measured using bubble-pressure transducer

Pathogens: refrigerated glass wool filtration; event-based sampling, not flow-weighted; qPCR measurements

Nutrients, sediment, and indicator *E.coli*: automated refrigerated sampler with time-based sampling

Controlled remotely by radio telemetry
Study Design – Paired Watershed

The relationship between two watersheds (i.e., fields) is compared between two time periods, calibration and treatment periods. Any shift in the regressions represents the treatment effect.

Example from Clausen et al. 1996
Treatments (Oct 2008 – April 2012)

- Fall Seeded Rye Cover, Spring Manure/Chisel Plow (Field 2)
- Fall Manure/Chisel Plow, Spring Cultivate (Control, Field 1)
- Fall Manure/Chisel Plow, Vegetative Buffers (Field 4)
- Fall Manure/Chisel Plow, Spring Chisel Plow (Field 3)
Calibration Period Regressions

Indicator *E. coli*

April – August, 2008
Calibration Period Regressions

Total Pathogens
(Sum of genomic copies across taxa)
April – August, 2008
Total Pathogen vs *E. coli* Concentrations, 2008-2010
Daily 2 Inch Soil Temperature vs *E. coli* Log Concentration
Year 2008

Pathogen Concentrations

- Cryptosporidium parvum
- Campylobacter jejuni
- Bovine Rotavirus A
- Bovine Enterovirus
- Salmonella enterica

Manure Pathogen Concentration (genomic copies/L)

Applied 11/8/07

Field No.

Runoff Volume m³/ha

Month
Year 2009

Pathogen Concentrations

Manure Pathogen Concentration (genomic copies/L)

- Applied 11/6/2008

- Campylobacter jejuni
- Bovine Rotavirus A
- Bovine Enterovirus
- Salmonella enterica
- Bovine Coronavirus
- EHEC

Field No.

Runoff Volume m$^3$/ha

Field 1
Field 2
Field 3
Field 4

Field 2 manure applied
Year 2011

Manure Pathogen Concentration (genomic copies/L)

Pathogen Concentrations

Field No.

Month

Runoff Volume m^3/ha
Year 2012

Manure Pathogen Concentration (genomic copies/L)

Applied
11/9/2011

Applied
5/1/2012

Pathogen Concentrations

Field No.

Jan  
Mar 
May 
Jul 
Sep 
Nov

Runoff Volume m³/ha

Field 1
Field 2
Field 3
Field 4
Pathogen Cumulative Export from Fall-Applied Manure

Caveat: Export values are not flow-weighted
Perennial forage phase established 2012
Pathogen types and concentrations in field runoff are highly variable.

Runoff may contain pathogens many months after manure application; e.g. rotavirus applied in Fall 07 ran off in April 08 and EHEC applied in April 2010 ran off 5 months later.

In four of the five study years, the majority of pathogen runoff occurred in the spring time.

Exposure risk to pathogen-contaminated runoff is not necessarily shown by measuring indicator *E. coli* because *E. coli* and pathogen quantities in field runoff are not related.

Estimated from export rates, fall-applied manure resulted in a 3 to 5 log reduction in pathogens in runoff.
Questions?