Manure-borne Microorganisms in Agricultural Environments
A few definitions...

- **Pathogen** = microbial agent causing disease
- **Enteric pathogen** = agent causing intestinal disease
- **Zoonotic pathogen** = a pathogen of animals that can infect humans
To Take Away...

• Pathogens are a concern in animal manure
  - Enteric Pathogens & others...

• Livestock can excrete high levels of some enteric pathogens infectious to humans

• Several characteristics enable enteric pathogen persistence and transmission in the environment

• Many exposure routes from livestock environments
To Take Away...

• Many data gaps concerning pathogens in Ag environments
  - Fate
  - Transport
  - Detection
  - Health Risks (human and animal)
  - Reduction strategies
  - Microbial ecology

• Pathogen research is closing in these gaps for multiple Ag environments but we have a long way to go!
Manure-borne Pathogens Implicated In Outbreaks of Disease

• New Jersey, USA *Salmonella typhimurium* outbreak apple cider (1974)

• Walkerton, Ontario *E. coli* O157:H7 & *Campylobacter* outbreak in drinking water supply (2001)
Waterborne Disease in the U.S.

- <20 drinking and recreational water outbreaks/yr
- **10–100 x higher**
  - This does not include foodborne outbreaks!
Water Sources That Can Be Threatened By Manure-borne Pathogens

- Recreational
- Irrigation
- Drinking
- Seafood
**Enteric pathogens most important in waterborne infections**

Enteric vs. Non-Enteric Pathogens Implicated in Waterborne Disease Outbreaks; 1991-2000

- Non-Enteric
  - Drinking water
- Enteric
  - Recreational/Surface Water
Manure-Borne Pathogens that May Threaten U.S. Water Supplies

Zoonotic Pathogens

Protozoan Parasites

Bacteria

Antibiotic Resistance

Enteric Viruses?

Other Pathogens

Microsporidia
Enteric Pathogens: Contributing Factors for Environmental Persistence and Transmission

- High numbers shed in feces
- Increased survival
- Low infectious dose
- Increased resistance to disinfection/treatment
- Multiple routes of transmission
- Animal and human infections
Agricultural Environments
More Animals...  
More Concentrated...

CATTLE, BROILERS, HOGS, TURKEYS  
POUNDS PRODUCED, 1953-2003

Billion Pounds


USDA-NASS  
April 2004
More Manure...

- Increase in CAFOs
- >500 million tons/year in U.S.
- 26 million tons/yr in NE
Livestock Environments

• Large amounts of manure produced
• High levels of pathogens excreted in manure
  - Up to 10,000,000 Cryptosporidium oocysts per gram of feces (calves)
  - ~3,000,000 E. coli per gram feces (cattle)
  - ~600,000 E. coli per gram feces (swine)
  - Young & sick animals ↑ levels
• Long duration of excretion
  - E. coli O157:H7: months
• Other sources: Insects, wildlife, inanimate objects (farm equip, shoes, etc)
Livestock Environments

Manure management practices can disseminate pathogens into water and air, onto soil and crops, or direct contact with inanimate objects or susceptible individuals (humans or animals)
Manure-borne Microbial Transport & Manure Management Practices

- Land application of manure solids
  - Irrigation of livestock wastewater
- Direct deposition
- Runoff from other manure laden areas (manure and compost piles, etc)
- Holding pond or lagoon overflow or leakage
- Other transport mechanisms
Land Application

- Manure Spreading
- Liquid Manure Injection
- Liquid Manure Spray Irrigation
Land Application & Aerosol Drift

Big Gun

Center Pivot
Solid & Liquid Manure Land Application

- Runoff
- Air transport
- Direct contact
- Vector transport
Direct Deposition
Runoff from Manure Piles
Other Ways Pathogens can be Transported in Ag Environments

- Insects
- Wildlife
- Farm Equipment
- Others
Manure-borne Pathogen Information Gaps

- Environmental Loading
- Environmental Fate
- Treatment Effectiveness
- Alternative Treatments/Tech.
- !!!Microbial ecology!!!

- Detection Methods
  - Viability
  - Sensitivity
  - Specificity
- Emerging Pathogens
- **Risk Assessments**
  - Requires above information
USDA-ARS Pathogen Research*

- Pathogen Detection Methods
  - Assessment and Development
- Bioaerosol Transport
- Antibiotic Resistance
- Cropland Runoff
- Constructed Wetlands
- Constructed Cattle Crossings
- Reclaimed Water Treatment
- Others

* Agroecosystem Management Research Unit, Lincoln, NE
**Microsporidium Detection Method**

- Sensitive and specific detection in manure
  - Detection down to 100/ml
    - Cattle and swine liquid and solid manure
  - Less sensitive detection in adult cattle feces
- First reported detection of human pathogenic microsporidia species in swine feces and wastewater

Bioaerosols

- Aerosol transport
  - Indicator and pathogenic bacteria

Findings: Fecal indicators and pathogen DNA was detected from 115 m & 81 m downwind of livestock liquid manure irrigation
Temporal Runoff Studies

Fate of Fecal Indicators in Manured Till and No-Till Cropland

(average of three plots per treatment; per sampling date)

Salmonella persisted for at least 121 days post application
Antibiotic Resistance

- Tetracycline Resistance
- Manured cropland
  - Growth promotion levels of tetracycline in feedlot cattle

- Temporary increases in tet resistant isolates was observed 7 months post application.
**Constructed Wetlands**

- Alternative waste management and treatment technology
- Dairy wastewater influent, surface flow, vegetated filter strip

- Contaminant reduction
  - Nutrients
  - Microbial pathogens
- Vegetation effects
- Microbial diversity
Constructed Dairy Wetland System
Dairy Cattle

Constructed Wetlands

<table>
<thead>
<tr>
<th>Unplanted Wetland % Reduction</th>
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<tbody>
<tr>
<td><em>E. coli:</em> 89</td>
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<tr>
<td>Enterococci: 83</td>
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<tr>
<td>Protozoa: 40–63</td>
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Constructed Cattle Crossings

- Cattle Use of Crossing
- Microbial Water Quality Impacts
Results: Cattle Movement

- Cattle Used the LWSC
  - During a 1 week period:
    - 80% of cattle stream crossings were at the LWSC
    - Microbial water quality data support collar data
Average time spent near stream (100 ft):
Collar 1............... 10.5%
Collar 2............... 8.9%

GPS Data Demonstrating Cattle Presence Nearby Stream
Results: Microbial Water Quality

- EPA 2o Contact Recreation standards exceeded during cattle presence & absence
  - Cattle Presence: 56% of samples assayed
  - Cattle Absence: 11% of samples assayed
Reclaimed Water in Ag Environments

• Use of reclaimed water for irrigation of food crops—Microbial water quality?

Food Safety

• Current Project:
• Assessment of alternative technologies for reduction of enteric viruses, protozoan parasites, and fecal indicators in reclamation water
• Bench and pilot scale studies
  – UV, ozone, others...
• Adenovirus mouse infectivity
Other Pathogen Projects

- Bioaerosol Transport Modeling
  - Manure Composting
- Innovative/alternative BMPs
  - Stream sediment stores
- Genetic analysis of pathogen and tetracycline resistant isolates
Manure-borne Pathogen Information Gaps

- Environmental Loading
- Environmental Fate
- Treatment Effectiveness
- Alternative Treatments/Tech.
- Microbial ecology!!!

Detection Methods
  - Viability
  - Sensitivity
  - Specificity

Emerging Pathogens

**Risk Assessments**
  - Requires above information
Questions/Comments?