

**Factors controlling subsurface transport of manure-borne pathogens**

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


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**Important manure-borne pathogens**

- Viruses
  - Rotavirus, Adenoviruses
- Bacteria
  - *E. coli* O157, *Campylobacter* spp., *Salmonella* spp., *Listeria* spp.
- Protozoa (parasites)
  - *Cryptosporidium parvum*, *Giardia lamblia*

Health concerns – gastrointestinal distress ⇒ death



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**Manure has potential to contaminate air, water, and soil with pathogens**

- Foodborne illnesses
  - Fields fertilized with improperly treated manure
  - Irrigating with contaminated water
  - Runoff water
  - Direct deposition (wildlife, escaped livestock)
- Waterborne illnesses
  - Drinking water
  - Recreation

Photos courtesy Jason Simmons



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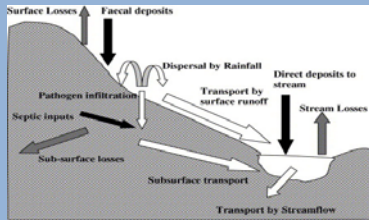
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### Pathogen transport pathways



Haydon & Deletic. 2006. J. of Hydrul. 328: 467 - 480

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### Risk of pathogen contamination of groundwater supplies

- GW was previously thought to have low vulnerability
- No longer assumed ⇒ EPA GW Rule



Diagram from Groundwater Forum

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### Fecal Indicator Bacteria (FIB)

- Pathogen monitoring is rarely conducted
  - Too many pathogens, expensive, time consuming
- Instead, nonpathogenic fecal indicator bacteria
  - If FIB are detected then water may be fecally contaminated
  - GWR ⇒ *E. coli*, enterococci, coliphage

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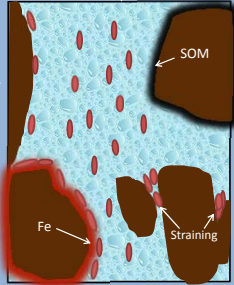
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### Factors affecting pathogen/indicator movement through soils and aquifers

**Geochemical**

- Soil solution ionic strength, composition, and pH
- Surface coatings on soil (Fe- and Al-oxides)
- Organic matter (including manure) present in solution and soil



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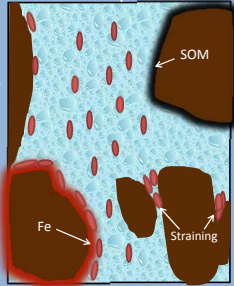
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**Physical**

- Pore-size distribution
- Flow rate
- Soil texture
- Presence of macropore flow
- Soil moisture content

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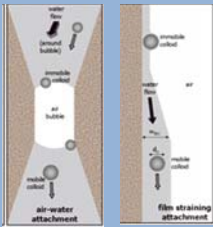
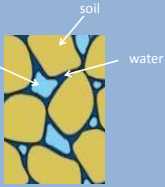
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### Unsaturated soil



DeNovio et al. 2004. Vadose Zone Journal 3:338-351

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**Biological**

- Size
- Motility
- Survival
- Surface properties
  - Surface charge & hydrophobicity

**Physical**

- Pore-size distribution
- Flow rate
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- Soil moisture content

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### Current Research

- Compare transport behavior of *E. coli* and *C. jejuni*
- Compare transport behavior of multiple *E. coli* isolates

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### Bacterial transport studies

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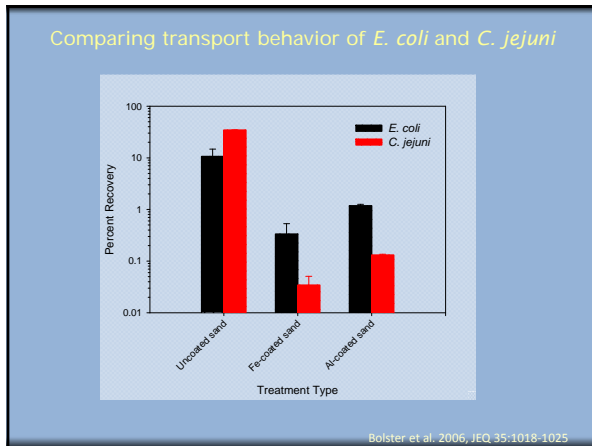
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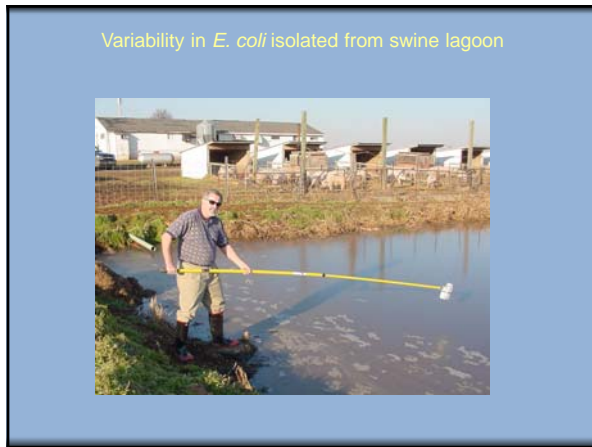
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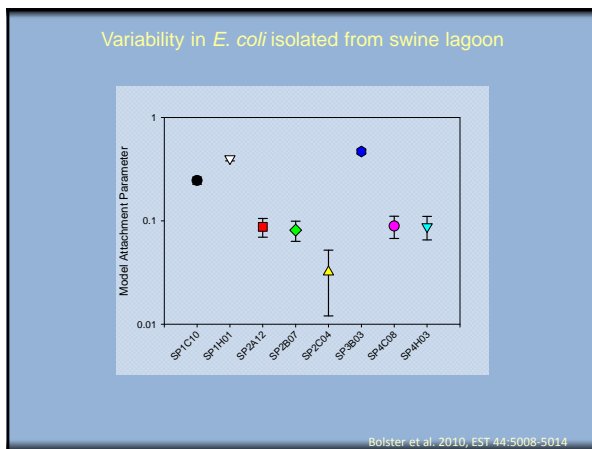
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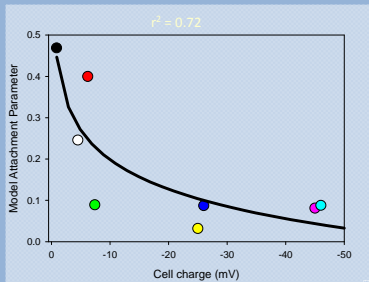
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Correlation between attachment rate and surface charge



Bolster et al. 2010, EST 44:5008-5014

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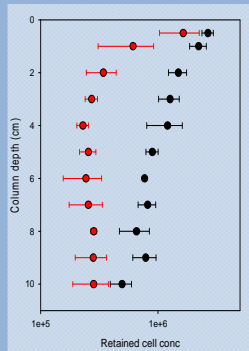
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Transport through soil of two swine isolates




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Significance

- Large inter-strain diversity exists for *E. coli*
  - Cell properties and transport behavior
  - True even for strains isolated from the same source
- Results from experiments using single *E. coli* cannot be generalized to all *E. coli*
- Modeling of *E. coli* transport will require a distribution of attachment rates
- Is this variability good or bad for an FIB?
- Implications for bacterial source tracking

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### Why the concern?

Total amount of manure produced in the U.S. exceeds 335 million tons dry matter yr<sup>-1</sup>



Photos courtesy of: A. Hargrett and USDA NREIS and MSU, Photo.net Site.

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### Proper manure management is required to reduce risk of infection from manure borne pathogens

Proper storage, treatment, and application methods



Photos courtesy of John Daugherty and Jason Simmons

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### Reducing leaching potential of pathogens from fields receiving manure

- Minimize water leaching below root zone
- Timing between water/liquid manure applications (die-off of pathogens)
- Consideration of water table depth



Transport and Fate of Nutrients and Indicator Microorganisms at a Dairy Lagoon Water Application Site

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Acknowledgements

- Dr. Kim Cook – USDA-ARS
- Dr. Sharon Walker – UC Riverside

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