Comparative Microbial Risks of Land Applied Municipal and Animal Manure Residuals

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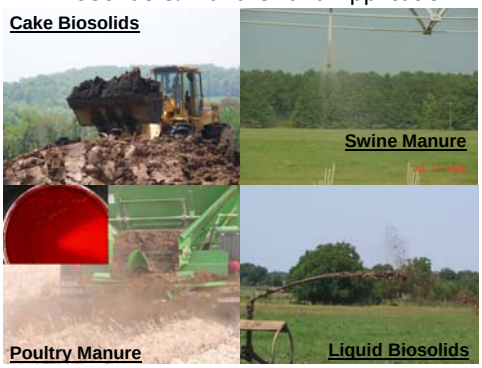
AFOs and Municipal WWTPs: Residual Wastes

- USA #s
  - Approximately 450,000 AFOs
  - Approximately 16,000 WWTP Producing
  - 100,000,000 dry tons/year manure
  - 5,600,000 dry tons/year biosolids
- What to do with it?
  - 0.1% ag land applied biosolids
  - 10% ag land applied manure

Biosolids & Manure Land Application



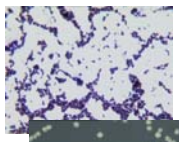
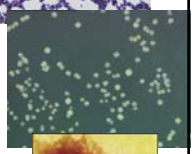
Municipal Biosolids & Manure Residuals

- Biosolids
  - Regulation - EPA Part 503 Rule
    - Class A – no pathogens
    - Class B – can expect pathogens
    - Reduces public interaction
    - Reduces pathogen/chemical loading
    - Site restriction
      - Access
      - Setback distances
    - Crop use/harvest restrictions
- Manure
  - Dairy, poultry, swine, etc.
    - Untreated manure is typical
  - Storage equates "treatment
  - No pathogen regulations
    - Recommendations or BMPs
- What are the risks?
  - Public & Occupational



QMRA Paradigm

- Hazard Identification
  - Pathogens & residual waste source
- Exposure/Contaminant Levels
  - Exposure Pathways & Modeling
- Dose Response
- Risk Characterization
  - 1 = 100% chance of something
  - 0.1 = 10%, aka. 1:10^1 chance
  - 0.0001 = 0.01%, aka. 1:10^4 chance

Pathogen Levels: Manure and Biosolids

Pathogen	Residual Source	CFU or PFU g^{-1}
Campylobacter jejuni	Manure	<2 - 7600
	RS/Biosolids	<2 - 3800
E. coli O157:H7	Manure	24-1200
Listeria monocytogenes	Manure	<1 – 3100
	RS/Biosolids	<1 - 1500
Salmonella	Manure	<1 – 4000
	RS/Biosolids	5 - 11000
Adenovirus	RS/Biosolids	<4 - 580
Coxsackievirus/Rotavirus	RS/Biosolids	<1 - 350
Norovirus	RS/Biosolids	1000 – $2x10^7$
Cryptosporidium	Manure	<1 - 180
	RS/Biosolids	<1 - 64

Exposure Pathways

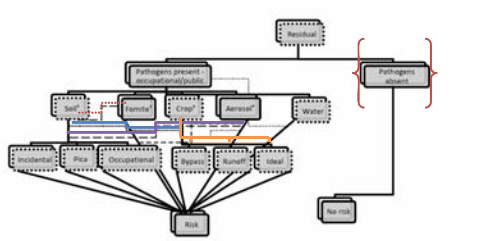


Figure 2: Schematic depicting the potential routes of exposure from a residual land application event. Dashed, elbow connectors represent secondary contamination, in which the primary contaminated matrix proceeds to contaminate the next matrix. Boxes with dashed lines represent poorly understood areas of the QMRA. *Represents routes of exposure modeled in the current study.

Modeling, Dose, & Dose Response Example

E.g. C = FC * SD * SDe * SRe * VWa

- Microbial concentration e.g. manure pathogen level
- Soil microbial dilution & decay
- Vegetable microbial attachment following harvest & wash steps
- Assume dose exposure
  - E.g. public vegetable consumption, occupational fomite exposure, etc.
- Dose response
  - B Poisson, Exponential, Hypergeometric models
    - Each pathogen has its own model and parameters

Risk Characterization

Fig 1A: Campylobacter Risk% - Day 0 Fomite

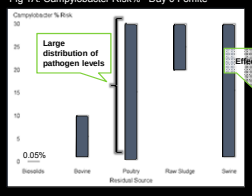


Fig 1B: Campylobacter Risk% - Day 7 Fomite

Fig 2A: Salmonella Risk% - Crop Ingestion – Bypass 7 d

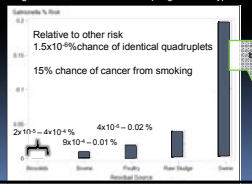
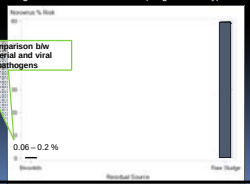


Fig 2B: Norovirus Risk% - Crop Ingestion – Bypass 7 d



Risk Validation

- Use 2006 *E. coli* O157:H7 spinach outbreak
  - Number of known cases, estimated number of infections, estimated number of contaminated doses in the public, size of the afflicted location
- Compared to risk model
  - Risk model predicted a risk of ~$3x10^{-3}$ using the high pathogen level
  - "Actual" risk was approximately $5x10^{-3}$
- Suggests high pathogen level (e.g. feral animals) or regrowth as suggested by others

Direct comparisons

- Manure vs. Municipal Residuals
  - Compared head to head with the same pathogen; manure has more risk
  - Compared head to head, municipal has more risk due to a low level of highly infectious pathogens
    - Manure has high levels of less infectious pathogens
- Treatment is inherent to protecting and reducing risk
  - Risk can be reduced by time and dilution
  - Possible use of wastes for fresh food crop growth with 4 month harvest delay; compared to 30-38 month

State of the science

- Relative to other risk: What is acceptable risk?
  - Risk context is inherently difficult to explain
    - Waste, environment, store shelf, exposure, etc. – All are dynamic
  - Microbial risk has many factors, known and unknown
    - Known – pathogen levels, ingestion, treatment (Y/N0), dose response, etc.
    - Unknown – pathogen behavior, inactivation, pathogen levels (e.g. VBNC), unknown pathogens, behavior based on waste residual, etc.

Questions & Thank You

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