



Pathogens 101: Viruses and Parasites in CAFO and Municipal Wastes

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Introduction: Viral and Parasitic Pathogens Important to Public Health through Land Application

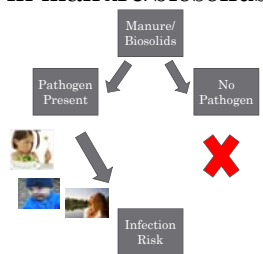
- 9.4 million foodborne illnesses
 - >50% are norovirus
- Viruses affecting public health are more common in municipal wastes (Class B biosolids)
- Parasites found in manure and biosolids
- There are many viruses in manure, but generally not infective to humans



Viruses/Parasites in manure/biosolids

Public exposure to manure/biosolids

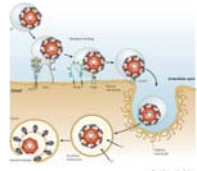
- Common routes are fecal/oral, dermal, or inhalation
- Viruses don't cross infect species
 - E.g. Swine virus may not infect people
- Parasites follow strict life cycles



Host specificity & parasitic life cycles

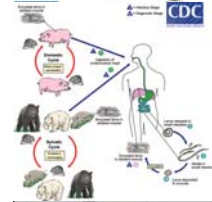
Example of Virus Specificity

- Viruses rely on specific host/virus receptors and cell replicative machinery



Example of Parasite Life Cycle



- Parasites rely on specific host/parasite life cycles



Manure Important Viruses

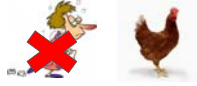
Hepatitis E Virus

- Associated with pigs
- Common in areas with water contamination
- Enteric transmitted hepatitis (i.e. liver inflammation)
- HEV infects pigs and humans

Avian Influenza and Coronavirus



- AI - wild birds & commercial birds
- H5 viruses have infected N. American birds, but no human infections
- Catastrophic in poultry
- Coronavirus - SARS/MERS
- Cause cold-like symptoms
- More difficult to spread in people



Biosolids Important Viruses

Enteric viruses

- Enteroviruses**
 - Very common - multiple types
 - Nervous system, hand/foot/mouth, diarrhea, cold-like symptoms, conjunctivitis, skin rash
- Norovirus (aka Norwalk)**
 - Diarrhea, vomiting
 - Cruiseship illness
 - "24 hr flu"

Adenovirus

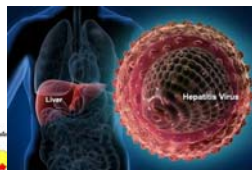
- Very common - multiple types
- Diarrhea, upper respiratory, conjunctivitis

Toilets

Class B Biosolids Important Viruses

Hepatitis A Virus

- Used to be more common, highly contagious, self limiting
- Transferred fecal/oral
- Outbreaks in restaurants
 - Green onions, frozen strawberries, etc.



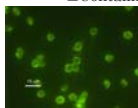
Manure and Class B Biosolids Important Parasites

Cryptosporidium parvum

- Bovine, ovine, human, other wild animals
- Oocysts are very resistant to environment, highly infectious
- Severe diarrhea, stomach pain
- Contaminated water, food
- Famous outbreak, 1993 Milwaukee

Giardia lamblia

- Bovine, ovine, human, wild animals
- Cysts resistant to environment
- Severe diarrhea
- Contaminated water, food



Nematodes or Infectious “worms”

Class B Biosolids

- *Ascaris lumbricoides*
 - Nematode infection, leads to intestinal blockage
 - EPA rules use *Ascaris* ova as marker for Class A biosolids classification
 - Typically below detection now in U.S.



- Others: *Trichinella*, *Taenia* in Swine
 - Nematode infections, common to contaminated meat not manure



Protection from Exposure

- No regulations determining levels of viruses or parasites in manure
- EPA set standards for enteric viruses and parasites in Class A biosolids, no regulation for Class B (fecal coliform only).
- Viruses die off relatively quickly, 1 – 14 d, while parasites persist

Table 3. Microbiological quality guidelines and standards for application of wastes to land.

Reference	Reuse conditions	Helicobacter	Fecal coliforms	Salmonella spp.	Enteric viruses
World Health Organization (1989)	crop fields to be sown one	<1:1	<1000/100 mL	NR	NR
World Health Organization (1999)	pasture and fodder and industrial crops	<1:1	<1000/100 mL	NR	NR
Bhattacharya et al. (2000)	crop fields to be sown one	<1:1	<1000/100 mL	NR	NR
Bhattacharya et al. (2000)	spray irrigation of pasture and fodder and industrial crops	<1:1	100 000/100 mL	NR	NR
USEPA (1993)	restricted irrigation of municipal Class A sewage sludge	1 fecal coliform/g total solids (dry weight)	10000 total solids	<3 to 4 g total solids (dry weight)	1 PFU/g total solids (dry weight)
USEPA (1993)	application of municipal Class B sewage sludge	NR	2 x 10 ⁶ total solids (dry weight)	NR	NR
State of North Carolina (1996)	land discharge of restricted domestic wastewater	NR	10000 mL	NR	NR
State of California (1970)	irrigation of food crops, high exposure landscape	NR	<2.2100 mL	NR	NR
State of California (1970)	irrigation of dairy pastures, low-exposure landscape	NR	<25100 mL	NR	NR

Outbreaks related to manure/biosolids

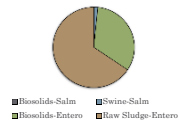
Table 2. Examples of manure-related human outbreaks (Smith and Perdek, 2003).

Location	Year	Pathogen	Impact	Suspected source
Walkerton, ON, Canada	2000	<i>E. coli</i> O157:H7 and <i>Campylobacter</i> spp.	6 deaths, 2300 cases	runoff from farm fields entering town's water supply
Washington County, NY	1999	<i>E. coli</i> O157:H7 and <i>Campylobacter</i> spp.	2 deaths, 116 cases	runoff at fairgrounds
Carrollton, GA	1989	<i>Cryptosporidium parvum</i>	13 000 cases	manure runoff
Swindon and Oxfordshire, UK	1989	<i>Cryptosporidium parvum</i>	516 excess cases	runoff from farm fields
Reading, UK	1994	<i>Cryptosporidium parvum</i>	125 cases	storm runoff from farm fields
Milwaukee, WI	1993	<i>Cryptosporidium parvum</i>	400 000 cases, 87 deaths	animal manure and/or human excrement
Maine and others	1993	<i>E. coli</i> O157:H7	several illnesses	animal manure spread in apple orchard
Sakai City, Japan	1990	<i>E. coli</i> O157:H7	12 680 cases, 425 hospitalized, 3 deaths	animal manure used in fields growing alfalfa sprouts
Cahoon, MO	1990	<i>E. coli</i> O157:H7	243 cases, 4 deaths	water line breaks in farm community

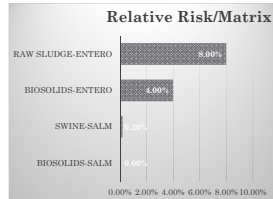
- Notice no viral outbreaks, typically biosolids not used for fresh food crops
- Viral outbreaks associated with food crops most likely not a result of applied fertilizer

Risk – Crop Ingestion, 7 d post application

Relative Risks/Matrix

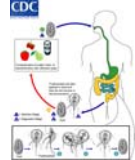


Biosolids: Class B biosolids
Swine – Pig manure effluent
Salm-*Salmonella*
Entero-Enterovirus







Note: Raw sludge is not land applied in US; Class B biosolids are not applied to fresh food crops

Take home points



- Bacteria are more numerous in manure and pose the greater risk in manure
- Very few viruses in manure, important to human health
- Viruses important to humans are present in municipal Class B biosolids
- Parasites important to humans are present in manure and biosolids



Questions

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