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# Approaches to Rational Microbial Risk Assessment of Treated Biosolids

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# Outline



Drexel

# Biosolids

Definition:

> *"Biosolids are the nutrient-rich organic materials resulting from the treatment of sewage sludge (the name for the solid, semisolid or liquid untreated residue generated during the treatment of domestic sewage in a treatment facility). When treated and processed, sewage sludge becomes biosolids. . ."*

Source: USEPA

# Route of Accumulation into Biosolids

Pathogens in wastewater may be reduced in several ways

1. Inactivation during treatment
2. *Physical removal into solids then separated*

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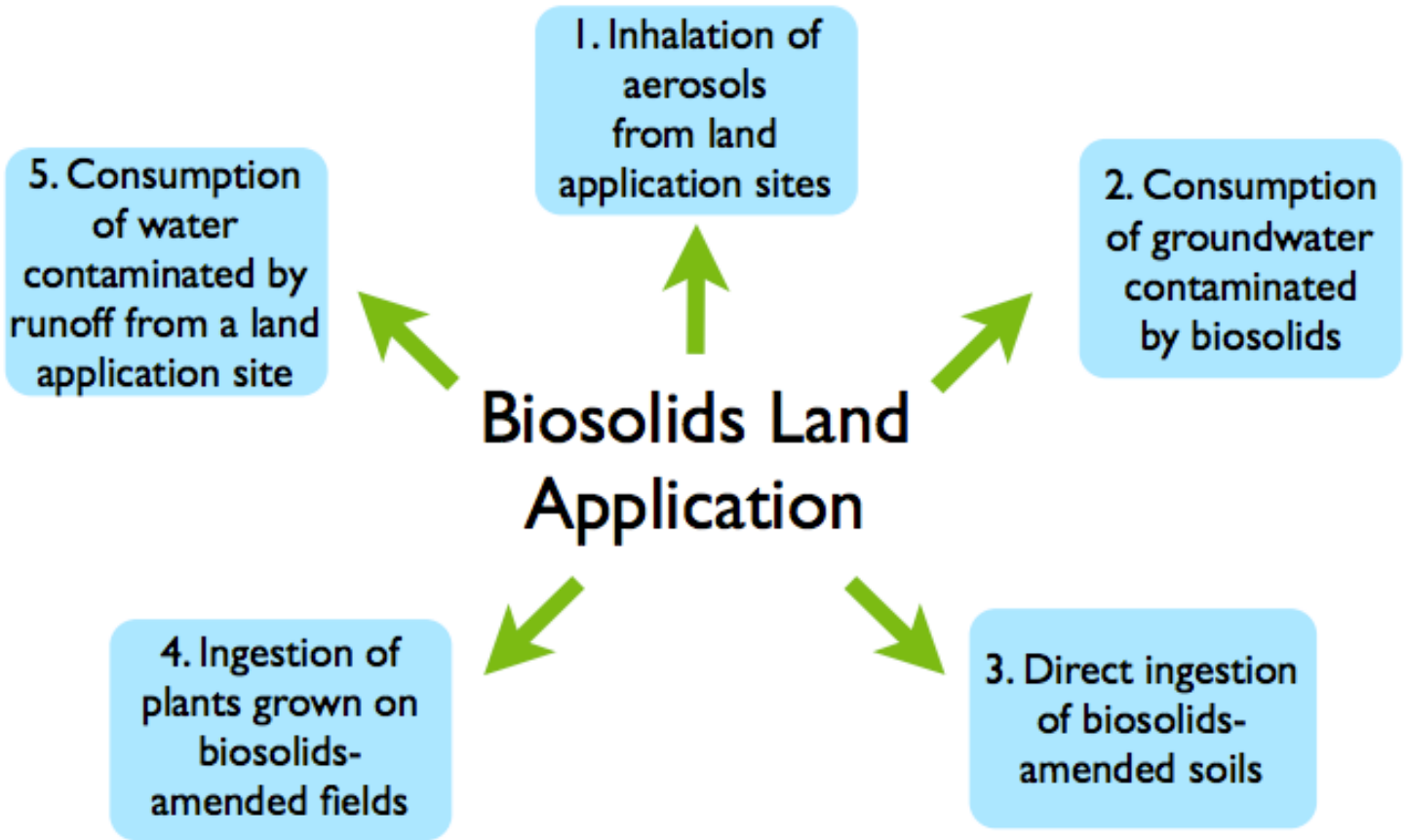
If the pathogens then survive sludge treatment, they will remain in the biosolids for disposal.

# Physical Application Methods

# Pathways




source: Teng *et al.*The Open Environmental Engineering Journal, 2013

# Biosolids Classification

## Many other (non-pathogen requirements) must also be met

- **Class B Biosolids** Require waiting time between application and public access, restriction on types of agriculture, and buffer zones
  - Requires a process for significant reduction of pathogens (PSRP)
- **Class A Biosolids** Can be applied to land without restriction
  - requires a process for *further* reduction of pathogens (PFRP)

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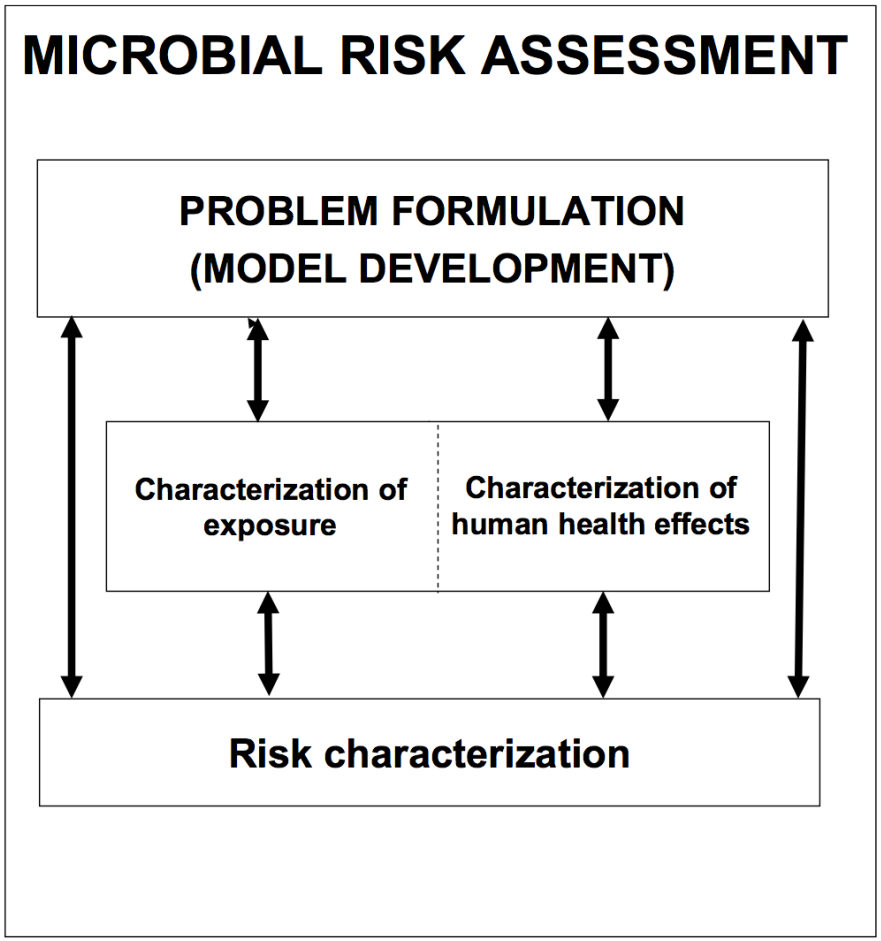
# Synopsis of Requirements

| | PSRP (B) | PFRP (A) |
|---|---|---|
| fecal coliforms | $< 2 \times 10^6/gm$ | $< 1000/gm$ |
| *Salmonella* | 1 log reduction | $< 3/4gm$ |
| enteric viruses | 1 log reduction | $< 1/4gm$ |
| viable helminths | — | $< 1/4gm$ |

Certain processes can be designated specifically as PSRP's or PFRP's if they can be shown to consistently meet these requirements

Note that none of this is explicitly risk based

# QMRA Process

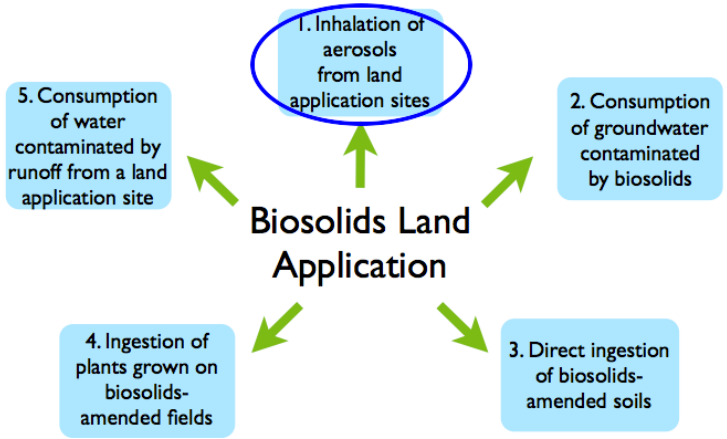



Source: US EPA

# Unique Aspects of Microorganisms

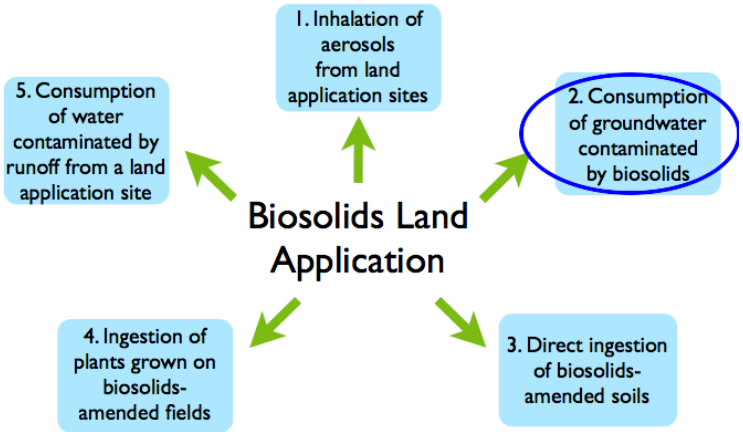
- Adverse effects may result from single or short term exposure
- Low concentrations lead to stochastic variability (Poisson and extra-Poisson)
- Therefore models must be capable of describing short term fluctuations in space and time
  - Most environmental fate & transport models have at least time averaging
  - Models of treatment processes have not been well developed to describe pathogen removal and its *variability*

# Data Needs—1



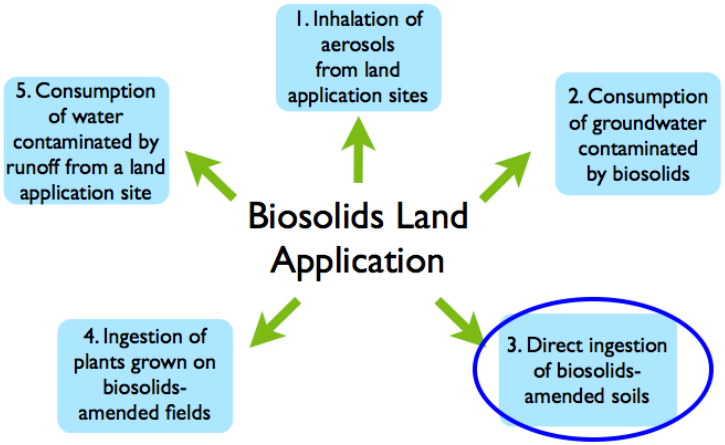

- Emission rates (size distributed) — varying climate, weather, application methods
- Near site air dispersion models with short averaging times
- Air decay rates of microorganisms — $f(RH, insolation)$

# Data Needs—2



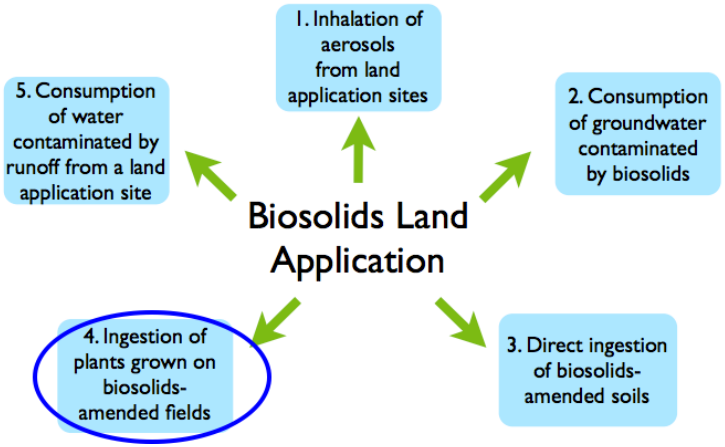

- Complexities of unsaturated flow transport
- Decay rates in saturated and unsaturated flow
- Filtration efficiencies, attachment, detachment
- Because microorganisms (or particle laden microorganisms) are low concentration, need stochastic models

# Data Needs—3



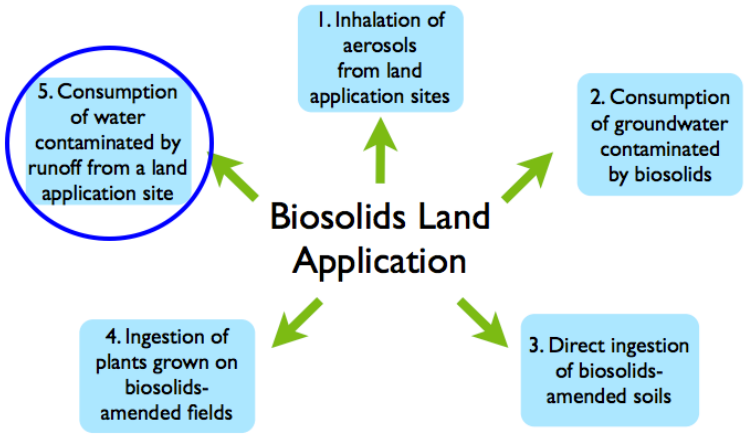

- Survival of pathogens on soil (surface)
- Effect of different application practices
- Soil-hand transferrence
- Eating (pica)

# Data Needs—4




- Decay in soil, migration into subsurface
- Incorporation of pathogens into edible plant tissue
- (Multiplication), survival and decay in plant tissue
- Impact of post- harvest handling (field to table)

# Data Needs—5




- Runoff and subsurface flow
- Decay and filtration removal processes
- Treatment of water supply (possible route might be shallow wells)

# Dose Response Data Gaps-1

We know that microbial dose response to bolus doses can be well described by:

$$p = 1 - \exp(-kd) \text{ (exponential)}$$

or

$$p = 1 - \left[1 + \frac{d\left(2^{1/\alpha} - 1\right)}{N_{50}}\right]^{-\alpha} \text{ (beta-Poisson)}$$

But describing multiple/repeated exposures remains a challenge

# Dose Response Data Gaps—2

- Missing data for some key pathogens
  - Helminths
  - Inhalation exposure to most agents (bacteria, viral, protozoal)
  - Dermal pathogens
- Sensitive and susceptible subpopulations — impact on infectivity

# Simplified Approach

*Send Orders of Reprints at reprints@benthamscience.net*

*The Open Environmental Engineering Journal*, 2013, *6*, 7-13 7

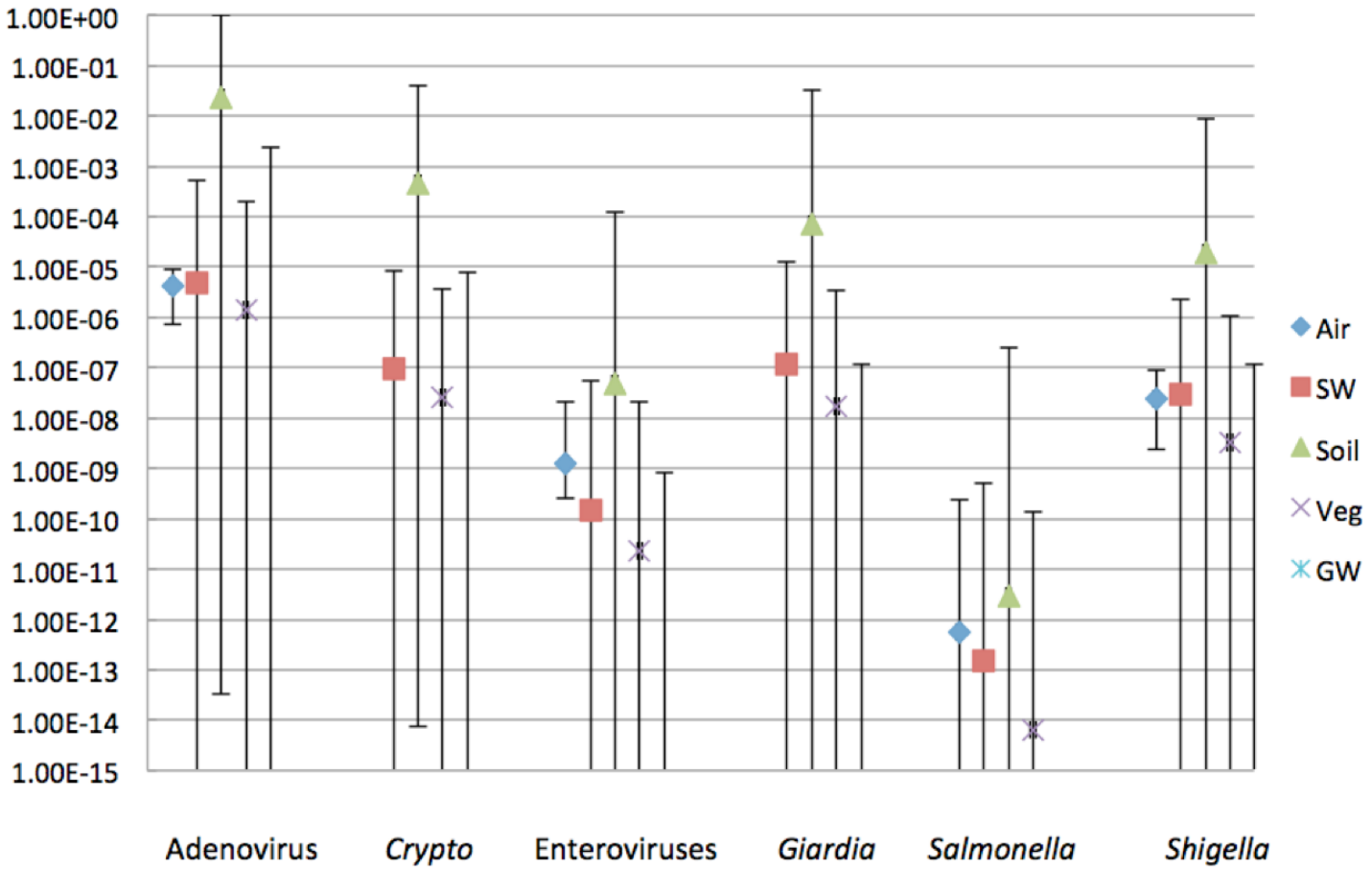
Open Access

**A Spreadsheet-Based Site Specific Risk Assessment Tool for Land-Applied Biosolids**

Jingjie Teng[1,*], Arun Kumar[2], Patrick L. Gurian[1] and Mira S. Olson[1]

- Steady state performance and transport
- Assume infectivity in air, water, dermal identical
- incorporation uncertainty & variability
- Calculations in a spreadsheet environment with visual basic macros

# Simplified Approach — Example Results




Cumulative risk from single land application.

# Research Needs

While we have the tools to do a "rough" screening level risk assessment, to do a more thorough job, there are many areas of research that need to be done (some not unique to biosolids):

- Dose-response data on pathogens of concern via routes of interest
- Integration of multiple doses and doses via multiple routes (PBDRMs)
- Process performance models for pathogen removal — incorporating variability in an explicit fashion. Need underlying basic data on process parameters impact on pathogens.
- Environmental fate and transport models predicting short term variability in exposure.

# Acknowedgements

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