Assessing the Fate of Emerging Pathogens in Biosolids

Experiments in the wind tunnel/lysimeter monitored the transport of the indicator microorganisms in controlled precipitation and wind events.

This research assessed the fate of several pathogens found in biosolids, e.g., adenoviruses, hepatitis A virus, *E. coli* O157:H7, *Listeria*, and *Cryptosporidium*, during Class A and Class B biosolids treatment processes. It assesses the fate and transport of the most significant organisms in biosolids applied to soil columns, and it examines the potential for selected pathogens to survive and move at a field site. The researchers found:

- Traditional indicators of biosolids treatment efficacy may not be the best indicators for emerging pathogens, and operators may need new indicators .
- The transport of many microorganisms, especially bacteria and parasites, through biosolids-amended soils is very limited, particularly in loam soils. Thus, the potential for groundwater contamination is small, although viruses may be able to move through some soils under certain environmental conditions.
- The transport of microorganisms in biosolids-amended soils depends on the specific microorganism of interest, but is relatively predictable based on size. Viruses, which are the smallest organisms, are transported to the greatest degree, followed by bacteria and then parasites, which are the largest. The research team determined that column experiments might provide accurate information regarding transport potential under field conditions.
- Another important finding is that microorganisms in biosolids are unlikely to become airborne; thus, the potential for off-site contamination appears to be minimal.

Research Looks at Survival of Pathogens After Land Application

The federal regulation on land application of sewage sludge, 40 CFR Part 503, requires that land-applied biosolids meet certain microbiological standards. For unrestricted use (Class A), these standards are based on a combination of treatment standards and indicator bacteria limits, i.e., fecal coliform bacteria, or a single pathogenic bacterium, *Salmonella*. Class B biosolids, which have undergone treatment processes to reduce but not eliminate pathogens, can also be used in land application programs if applicators observe specified access and use limitations.

To address potential public health concerns over a number of pathogenic microorganisms

BENEFITS

- Provides utilities and others information on siting, monitoring, and operating procedures for land application activities based on soil characteristics, groundwater formations, and climate conditions.
- Provides regulators and researchers a greater understanding of the fate and transport of viruses, bacteria, and parasites in land-applied biosolids.

RELATED PRODUCTS

Control of Human Parasites in Municipal Biosolids (99HHE3)

Quantification of Airborne Biological Contaminants Associated with Land Applied Biosolids (02PUM1)

RELATED ONGOING RESEARCH

Biosolids Research Challenge (SRSK1R07)

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in biosolids, we gathered data on their fate in biosolids treatment processing as well as their ability to survive and move in the environment after land application.

The research team approached their work in three phases:

- Phase 1 assessed pathogens' relative potential for survival. Researchers added pathogens, including selected bacteria, viruses, and parasites, to water and/or microcosms to simulate Class A and Class B treatment processes. They chose the organisms that survived in the highest numbers or in numbers that represent the highest risk for further study. These organisms were *E. coli*, *Clostridium perfringens* spores, *Listeria innocua*, and bacteriophage ϕX174.
- Phase 2 involved spiking treated biosolids with the pathogens, then applying the material at typical rates to soil columns.
- Phase 3 evaluated the transport and fate of the chosen organisms in a field setting. Researchers used a lysimeter to allow for collection of unsaturated soil samples, groundwater samples, runoff samples, and air samples.

Traditional Indicators Might Not be Adequate

The laboratory inactivation studies revealed that the organisms traditionally used to indicate treatment efficacy might not be adequate indicators for emerging pathogens.

- This was especially true for the bacteria, as the team found that *L. innocua* and *M. fortuitum* were more resistant to most of the treatment processes than *E. coli* or *Salmonella*.
- Bacteriophage ϕX174 was more resistant to all treatment processes (with the exception of lime treatment, where MS2 was more resistant) than the pathogenic viruses studied.
- In the case of the parasites, *C. perfringens* spores were the most resistant overall; however, their extreme resistance to many of the treatment processes may be overly conservative.

Pathogen Transport Through Soil or in the Air is Minimal

Neither *C. perfringens* spores nor *L .innocua* were found to move through the soil columns, regardless of soil type or flow rate. *E. coli* was able to grow in the columns run at 22°C. As expected, ϕX174 exhibited the greatest potential for transport through the soils.

The results of the column studies closely mirrored those of the field studies. Researchers observed more transport in the sand than in the loam soil; they detected no microorganisms in any of the air samples collected.

The present findings indicate that *L. innocua* remains in biosolids-amended soil, regardless of soil type, temperature, and water flow velocity. Adsorption and natural die-off are the major mechanisms to retard bacterial mobility and, if there is less adsorption, natural inactivation is able to inhibit the transport of cells through soil matrix. These results indicate that *L. innocua* has minimal ability to move to the groundwater table. Thus, there appears to be a very low potential risk of groundwater contamination from land application of biosolids containing *L. monocytogenes*.

These results need to be verified with field studies and/or mathematical modeling. Determination of the survival rates and adsorption coefficients in this study will enable further extrapolation on movement of the bacteria for longer periods through computational modeling.

Survival of Microorganisms in Soil

Organism	Absolute Maximum	Common Maximum
Bacteria	1 year	2 months
Viruses	6 months	3 months
Protozoa	10 days	2 days
Helminth ova	7 years	2 years

CONTRACTOR

Marylynn V. Yates, Ph.D.
University of California, Riverside

PROJECT TEAM

Wilfred Chen, Ph.D.
University of California, Riverside

Ashok Mulchandani, Ph.D.
University of California, Riverside

Shawn S. Thompson, Ph.D.
County Sanitation Districts of Los Angeles County

William A. Yanko
Consultant

Scott R. Yates, Ph.D.
USDA/ARS

PROJECT SUBCOMMITTEE

Prakasam Tata, Ph.D. (Chair)
Tata Associates International

Geeta Rijal
Metropolitan Water Reclamation District of Greater Chicago

Joel Alpert
Consultant

Zia Bukhari, Ph.D.
American Water Works Service Company

Jim Crook, Ph.D., P.E.
Environmental Engineering Consultant

Rick Danielson, Ph.D.
BioVir

Mark Meckes
U.S. Environmental Protection Agency

Lynn Moss, P.E.
Camp Dresser & McKee

Paul Rochelle, Ph.D.
Metropolitan Water District of Southern California

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