Quantification of Airborne Biological Contaminants Associated with Land Applied Biosolids

The results from field experiments suggest that, through the aerosol route, there is potential for human exposure to biosolids material at downwind locations that exceed common setback distances promulgated by most U.S. states. The dose of respirable biosolids material from a single land application event is a function of source strength, exposure time, and aerosol transport phenomena.

The investigators urged caution in applying this summary statement to judge the safety of land application, however. Different application techniques and environments will result in different doses, and neither pathogen nor toxin dose-response relationships in humans are well described for respirable biosolids.

This research paired a comprehensive literature review with field results to investigate the concentration, transport, and type of bioaerosols generated during land application of Class B biosolids.

Background

More than seven million dry tons of biosolids are generated in the U.S. annually. Increases in population served by sewers and advances in treatment have resulted in a greater than 50% increase in the amount of biosolids produced since 1972. The U.S. EPA estimates that 8.2 million tons will be generated, per year, by 2010.

Biosolids can be reused through land application, incinerated, or disposed of in landfills. Several factors have shifted practices toward beneficial land application, with approximately five million tons of biosolids applied to agricultural land in 40 states in 2000. Land application conditions the soil, resulting in slower and steadier nutrient availability unmatched by conventional chemical fertilizers. Federal and state regulations (Part 503 of EPA Biosolids Rule) encourage recycling and beneficial biosolids use rather than disposal.

There are also environmental and public health concerns. A 2002 National Research Council report concluded that although there is no documented scientific evidence that Part 503 has failed to protect public health, there is a need to address scientific and management questions and uncertainties that challenge EPA's biosolids standards. They recommended that EPA expand its biosolids oversight activities to include: assessing the reliability of the biosolids treatment processes; monitoring compliance with chemical and pathogen standards; conducting environmental hazard surveillance; and studying human exposure and health.

Regarding on-site and off-site exposure, the NRC report also stated that exposure pathways such as inhalation were not adequately evaluated by the 40 CFR, Part 503 rule and that there is little knowledge about pathogen transport and survival in air. While restricting access to the site controls the inhalation of dust on-site, the 40 CFR, Part 503 rule does not consider potential off-site exposure due to aerosolization and subsequent transport of biosolids derived chemicals and microorganisms. These aerosols may be generated during biosolids loading spreading onto land, disk incorporation into agricultural soils, and potentially through subsequent soil disturbance caused by high wind events.

BENEFITS

- Reviews literature on production and health effects of aerosols produced during biosolids land application.
- Describes particulate matter size and mass, metals concentrations, and biological characteristics of biosolids-derived bioaerosols.
- Quantifies aerosol emission rates from side slinging and disking, and identifies disking as the major mode of aerosol production.
- Confirms the use of a simple transport model to estimate downwind biosolids bioaerosol concentrations.
- Proposes a framework for estimating on-site worker and off-site resident toxin or pathogen exposure.

RELATED PRODUCTS

Public Perception of Biosolids Recycling: Developing Public Participation and Earning Trust (00PUM5)

Development of a Metals Toxicity Protocol of Biosolids (00PUM6)

Assessing the Fate of Emerging Pathogens in Biosolids (01HHE3)

RELATED ONGOING RESEARCH

Challenge: Optimization of Wastewater and Solids Operations (OWSO1)

AVAILABLE FORMAT

Soft cover and online PDF.

TO ORDER

Contact WERF at 703-684-2470 or visit www.werf.org and click on Publications.

WERF Subscribers:
Your first copy of this report is free. Additional copies are $10 each or download unlimited free PDFs at www.werf.org.

Non-Subscribers:
Hardcopy: $165 PDF: $50

Refer to: **STOCK NO. 02PUM1**

For more information, log on to **www.werf.org**

Knowledge Gaps Exist

The researchers found insufficient literature to accurately describe the potential for biosolids-derived bioaerosols to cause on-site worker and off-site public health impacts. Biosolids bioaerosol studies have not yet definitively measured all relevant etiological agents and exposures. In addition, relevant epidemiology and risk studies are limited in scope and number and have inconsistent conclusions. Critical knowledge gaps exist in:

- quantification of concentrations of the multitude of pathogens associated with both gastrointestinal and respiratory disease;
- accuracy of aerosol transport modeling and biosolids source emission rate;
- high volume samplers and molecular biology-based microbial characterization techniques in biosolids bioaerosol studies;
- prospective epidemiology studies on biosolids workers and residents who live in areas near land application sites (public health outcomes should include serial measures of symptoms, lung function, and serology);
- retrospective epidemiology studies in areas where anecdotal allegations of negative public health effects were reported after exposure to biosolids; and
- toxicology studies evaluating the health effects of biosolids pollutants to determine if an effect exists via the inhalation route.

Field Study Background

The field study was conducted at land application sites in Central Arizona. Applied biosolids were class B and stabilized by mesophilic anaerobic digestion. All experiments used dewatered biosolids in areas with dry, sandy soils to test a worst case scenario for aerosol production. There were three specific tasks: 1) determine the physical, chemical, and biological concentrations and source emission rates of biosolids aerosolized during land application by side slinging as well as during biosolids disk incorporation; 2) estimate the extent to which high winds can aerosolize biosolids from fields that have had previous applications; and 3) estimate the extent of off-site transport of biosolids bioaerosols created during a high emissions activity.

Recommendations for Additional Research

This research forms a basis for targeted recommendations in the areas of bulk biosolids monitoring, aerosol exposure measurements, and health effects studies.

Pathogen and Toxin Measurements: Create a comprehensive, quantitative database of pathogens and biotoxins in biosolids.

Aerosol Measurements: Further develop and characterize high-volume samplers .

Health Studies: Perform risk analyses for infectious and noninfectious airborne agents. Evaluate *in vitro* and *in vivo* toxicity of biosolids to determine if there is an effect via the inhalation route.

Exposure Assessment Framework

Future biosolids bioaerosol health effects studies will only result in tangible guidance if pathogen and toxin exposure is accurately estimated. This study provides a fundamental framework for extending future biosolids and agricultural waste aerosol research towards estimating exposure to infectious and toxic aerosols. First, determine source aerosol concentration for onsite worker exposure; next, estimate source emission rates; and finally, apply transport and exposure time modeling to estimate the dose for offsite receptor(s). This framework allows estimation of aerosol information without the expense, difficulty, and limitations of aerosol sampling. It allows for efficient aerosol monitoring of a diverse set of biosolids concentrations and application scenarios.

CONTRACTOR

Jordan Peccia, Ph.D., P.E.
Yale University (formerly with Arizona State University)

PROJECT TEAM

Morteza Abbaszadegan, Ph.D.
Arizona State University

Ronald Calhoun, Ph.D.
Arizona State University

Maria Patricia Fabian, M.S.
Harvard University

Donald Milton, M.D., Dr. PH
University of Massachusetts-Lowell

Tania Paez-Rubio, Ph.D.
Arizona State University

PROJECT SUBCOMMITTEE

Michael D. Jawson, Ph.D.
U.S. Geological Survey

Joanne Jones-Meehan, Ph.D.
Department of Homeland Security

Charles W. Purdy Ph.D., D.V.M.
United States Department of Agriculture

Mark Rupke, P. Eng,
City of Toronto

Stephen Schaub, Ph.D.
U.S. Environmental Protection Agency

COLLABORATORS

City of Phoenix, Arizona

Synagro Technologies Inc.

The research on which this report is based was funded in part by the U.S. Environmental Protection Agency (U.S. EPA) through Cooperative Agreement No. CR-83155901 with the Water Environment Research Foundation (WERF). Unless an U.S. EPA logo appears on the cover, this report is a publication of WERF, not U.S. EPA. Funds awarded under the agreement cited above were not used for editorial services, reproduction, printing, or distribution.

10/08