



CINCINNATI, OHIO JANUARY 2006

DEVELOPMENT AND REVIEW OF MONITORING METHODS AND RISK ASSESSMENT MODELS USED TO DETERMINE THE EFFECTS OF BIOSOLIDS LAND APPLICATION ON HUMAN HEALTH AND THE ENVIRONMENT

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LTG 4 Poster 01

Science Questions

MYP Science Question:

What additional models, tools and methods are needed to identify measure and assess aggregate exposure pathways and risks?

Research Questions

-How should the chemical and microbial contaminants released during the land application of class B biosolids be characterized?

-How should contaminate transport and human exposure be measured during and after land application of class B biosolids?

-What data are needed to conduct microbial risk assessment on pathogens from land applied biosolids?

How Research Addresses the Water Quality MYP Goals

The focus of this research is improving and developing sampling and analytical methods for measuring contaminants associated with the land application of biosolids for the purpose of better assessing the possibility of risk posed by constituents in biosolids. These methods will be used to monitor contaminant transport and human exposure. These data will be used to populate models to assess the risk of pathogens and chemicals in biosolids. The first step in conducting a pathogen risk assessment is the problem formulation phase. The problem formulation helps focus method development on areas not adequately addressed with current technology. These improved approaches to characterizing releases and determining exposures should result in more effective protection of human health through improved biosolids management practices.

Research Objectives

- Optimize various air, land, and water sampling methods for use during land application of biosolids
- Evaluate the efficiency of the optimized techniques during application
- Evaluate how the release of air-borne and soil-bound contaminants is affected by both biosolid composition and application method by building a database of analyzed samples
- Recommend monitoring protocols for measuring human exposure to contaminants from biosolids land application, surface disposal, and reclamation practices.
- Develop a microbial risk assessments based on exposure to constituents during and after biosolids land application practices.

Biosolids Application NC Study



Biosolids Distribution NC Study



Research Methods & Collaboration

NRMRL has conducted a field study in North Carolina (2004) evaluating land applied biosolids for various air and soil contaminants. This field study focused on evaluating and optimizing several sampling and analytical methods. Samples were taken and evaluated for volatile organic and inorganic compounds, odor, bioaerosols, particulates, and soil type. The sampling for volatile organic and inorganic compounds and odors was both at the small localized and large field scale. The bioaerosol, particulate, and soil type samples were physically characterized and evaluated for chemical and/or microbiological properties. This study involved researchers from NRMRL, OW, NHEERL, Region 5, USDA, NC State University, other North Carolina state agencies and citizens groups.

NERL will conduct a Biosolids Exposure Measurement Workshop in the spring of 2006. The workshop will identify exposure measurement tools both available and needed to investigate human exposure related to land application of biosolids. The results of this meeting will be used to prioritize methods development needed to both assess risk and determine human exposure.

NCEA is in the initial phase of microbial risk assessment planning which is a problem formulation and analysis plan. This plan consists of three components: identification of the valued entity and desired condition, development of conceptual models, and an analysis plan that lays out an approach to conducting assessment of microbial risks.

Research Results

North Carolina Biosolids Land Application Methods Evaluation Study

Volatile Organic and Inorganic Compound and Odor Measurements

- OP-FTIR evaluated the dispersion of chemical contaminants
 - Field Olfactometry (Nasal Rangers) measures relative odor
 - Flux Chamber Sampling measured the level of volatiles compounds by: Summa Canister Olfactometry SPME

Bioaerosol and Particulate Sampling Measurements

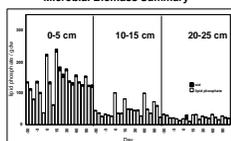
- Impingers and Anderson 6-stage Samplers were used for microbiological sampling
- Button Samplers were used to detect endotoxin
- High Volume Impaction Sampler was used to determine volume of particulates
- GRIMM Dust Monitor was used to determine size fractions of particulates

Land Sampling Measurements

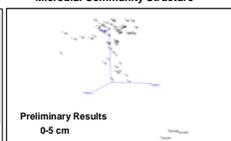
- Cores from three depths 0-5, 10-15, 20-25cm, were taken and evaluated using the following tests

- FAME Microbial Community Analysis by phospholipid fatty acid analysis
- Total Heterotrophs and Fecal Coliforms
- Selected Microbial Indicators (Enteric viruses, Coliphage, Helminth Ova, *Salmonella*)
- Nonylphenol and Octylphenol
- Ecotoxicity by earthworm toxicity and root elongation
- Agrotoxic Soil Characteristics
- Biosolids distribution

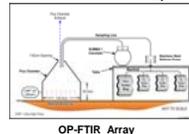
Microbial Biomass Summary



Microbial Community Structure



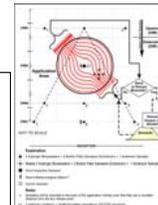
VOC Flux Chamber Setup



OP-FTIR Array



Bioaerosol Sampling Plan



Research Conclusions & Future Directions

The land application study demonstrated the limitations of some of the methods employed. Some of the issues that arose during this study included difficulty obtaining representative samples, result variability, problems with placement of sampling equipment, and the lack of assay sensitivity and specificity. Also, some test methods that were grouped due to similarity of sampling, such as FAME and nonylphenol, could not be grouped because sample size was not adequate for both tests variability. Furthermore, the methods for sampling and analyzing bioaerosols need improvement; in particular the appropriate placement of bioaerosol monitoring equipment needs to be determined so that more accurate monitoring of the movement of contaminants offsite can be done. In the future NRMRL will be working on improving sensitivity and selectivity of microbial methods. NRMRL will continue this work at full scale application sites by collaborating with academia and Region 5. Some smaller more detailed studies to improve sampling techniques will also be performed. The Biosolids Exposure Measurement Workshop in early 2006 will focus on human exposure. The results of this workshop should help the Agency better identify and develop better methods to evaluate the impact of biosolids. This workshop along with the field studies will help in supplying quality data for future risk assessment. Finally, the first step in risk assessment, the problem formulation and analysis plan, is currently under review. This document will also help to identify areas where data is lacking and help shape future research. A biosolids application database/matrix will be developed in order to help assess the risk of exposure for a specific site incorporating such highly variable factors including sewage sludge source, composition, processing; soil type, climate, and land application/field management practices.

Assessment of Pathogenic Risks

Problem formulation lays out the scenarios for conducting risk assessments on biosolids-borne microorganisms.

A problem formulation exercise is used to define:

Identification of Valued Entity (The Endpoints)
 -Applicers, Farm Family, and Nearby Residents

Desired Condition

-Health Status of the Entity that is Comparable to Nonexposed Individuals

Conceptual Exposure Models

-Direct Dermal Contact with Hand to Mouth Exposure
 -Waterborne Exposure from Runoff or Leaching
 -Aerosol Exposure to Airborne Stressor

Analysis Plan

-Review Literature for Models and Data on Exposure to Pathogens

-Assess Utility of the Models

-Assess Quality of the data

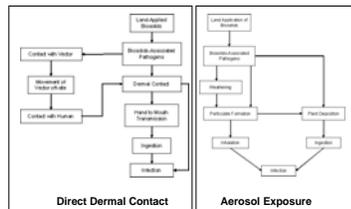
-Establish Site-Specific Conditions

-Match Conditions to Models and Data

-Assess Exposure to Pathogens

-Validate with Measured Data

-Compare Infection Incidence with Epidemiological Information



Interactions with Customers

Key Clients: -OW
 -Regions

ORD through the National Biosolids Conference is working with OW, the Regions, and states to better define problem areas in biosolids application. ORD is working with OW and the Regions in method development and identification of sites of interest.

The North Carolina methods review study was done with the input of a public information sharing group. The data report from that study will be released after input from this group. Better sampling and analytical protocols developed in-house and identified through Biosolids Exposure Measurement Workshop will be used to construct a database of biosolid application method and which protocols are appropriate. This and future data will better characterize contaminants and allow for better assessment of human exposure.

The problem formulation will ultimately serve to inform the federal, state, or private assessor on how to proceed with conducting a risk assessment. The problem formulation and analysis plan document will serve as a communication tool for interacting with regulators and the general public.

ORD is addressing the need to understand the many factors affecting chemical and microbial movement from land use practices and how this affects human exposure. The information on variability will be compiled in a matrix of biosolid type, application method, and which protocols should be used to assess contaminants of interest. This information will help to inform, define, and build better risk assessment models. It is anticipated that ORD in conjunction with OW and Regions will conduct the pathogen risk assessment for specific sites allowing for better management practices to minimize human exposure to land applied biosolids. This information develops a foundation on which researchers outside and within the U.S. EPA can structure future pathogen risk assessments. Also, the degree that the format of these outside organizations deviates from the analysis plan, the document will provide a point of comparison.

How Research Contributes to Outcomes

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