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Research and Development

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EPA

Project Summary

Preliminary Risk Assessment for Bacteria in Municipal Sewage Sludge Applied to Land

Section 405 of the Clean Water Act requires the U.S. Environmental Protection Agency to develop and issue regulations that identify: (1) uses for sludge including disposal, (2) specific factors (including costs) to be taken into account in determining the measures and practices applicable for each use or disposal, and (3) concentrations of pollutants that interfere with each use or disposal. To comply with this mandate, the U.S. EPA has embarked on a program to develop four major technical regulations: land application, including distribution and marketing; landfilling; incineration; and surface disposal. The development of these technical regulations requires a consideration of pathogens as well as chemical constituents of sludge. Public concern related to the reuse and disposal of municipal sludge often focuses on the issue of pathogenic organisms.

This report is one of a series whose purpose is to use the methodology described in *Pathogen Risk Assessment for Land Application of Municipal Sludge* (EPA/600/6-90/002a,b) to develop preliminary assessments of risk to human health posed by parasites, bacteria, and viruses in municipal sewage sludge applied to land as fertilizer or soil conditioner. The preliminary risk assessment includes a description of the most critical data gaps that must be filled before development of a definitive risk assessment, and recommends research priorities.

This Project Summary was developed by EPA's Environmental Criteria and Assessment Office, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This preliminary risk assessment study focuses on the probability of human infection from enteric bacterial pathogens in municipal sludge applied to land. It is based on the Pathogen Risk Assessment computer model and methodology described in *Pathogen Risk Assessment for Land Application of Municipal Sludge.*

This document reports the results of a literature review designed to find the data on pathogenic bacteria required by the pathogen's methodology, and the results of numerous site-specific computer simulations, running the Pathogen Risk Assessment Model with a wide range of values for the parameters required. The parameters required for bacteria are (1) minimum infective dose; (2) density of viable bacteria in treated sludge destined for land application; (3) die-off rates in soil, dry particulates, liquid aerosols, and water; and (4) dispersion in the environment, i.e., transport in water, soil, and air.

Procedure

Six sites were chosen to provide diversity in geographic location, topography, soil type, rainfall pattern, and temperature. Locations selected for site-specific application of the model include Anderson County, TN; Chaves County, NM; Clinton

County, IA; Highlands County, FL; Kern County, CA; and Yakima County, WA.

An initial sensitivity analysis was performed using site-specific parameters for Site 1, Anderson County, TN. Main program variables used in the model run were varied over a range of values to determine the sensitivity of the model to variations in conditions. In general, the default value of a given parameter was compared with a reasonable higher and a reasonable lower value, where the high and low values were taken from available literature or estimated when literature values were not available.

In this analysis, it is assumed that bacteria are transported into subsurface soil and subsequently into groundwater and are included in any droplet aerosols formed by spray application, as well as in any particulate aerosols formed by disturbance of the soil by wind or by cultivation. It is also assumed that the bacteria die at a characteristic rate that depends on the ambient temperature and the medium in which they are found.

Conclusions

The risk of infection from bacterial pathogens in treated sewage sludge appears to be small when judged by model results, but there are a number of factors the model does not address, including regrowth in composted or D&M sludge. The model runs indicated that significant exposures are likely only if the number of organisms is very high, either because the concentration of bacteria in the treated sludge is unrealistically high or because a high application rate is used. Significant exposures occurred only onsite, either by direct contact or by swimming in a pond containing runoff. However, runoff and surface transport of bacterial pathogens to the onsite pond do not appear to present a major health risk. Exposure by direct contact immediately after sludge application could be a source of infection, although the risk of infection decreases very rapidly, so that the cumulative risk of infection from a single application is typically only slightly higher than the maximum daily risk. The results suggest that if the infective dose is >20, the probability of infection becomes minimal.

The results of the model runs clearly indicate that the highest risk of infection should occur during and immediately after application of the sludge. Die-off and dilution by soil should subsequently reduce the number of infectious organisms very rapidly. Aside from the expected dependence of exposure on total numbers of pathogens present and the infectious dose, the most significant effects on exposure appear to be related to die-off rates and to dry particulate aerosol formation. Fractional transfers of pathogens from soil to subsoil and to soil surface water were also significant, as was the volume of the onsite pond in which the contaminated soil surface water was diluted.

The results described above do not support the requirement for an extended waiting period before use of sludge-amended soils. Bacterial concentrations in all of the exposure media decreased so rapidly that a waiting period of a few days at most should be sufficiently protective. However, compost and D&M sludge products designed for use in the home garden can allow multiplication or regrowth of bacteria, such as *Salmonella*, resulting in extremely variable pathogen densities and the possibility of a higher dose of pathogens upon ingestion of crops.

Recommendations

The following information is needed to improve the usefulness of the Pathogen Risk Assessment Model and to allow for more reliable risk assessment of land application of sewage sludge:

- Simple and accurate standardized methods for quantifying, by species and strain, pathogenic bacteria in treated sludge destined for land application, in final distributed and marketed (D&M) sludge products, and in environmental media;
- Improved understanding of minir infective doses, particularly low-dc effects and MIDs for sensitive subjects;
- Additional information on regrowth of bacteria in compost and D&M sludge, including factors enhancing or limiting regrowth;
- More accurate survival and transport data on all pathogenic bacteria of major concern in sludge, especially retardation coefficients for transport of bacteria in saturated soil;
- Development of an index of soil types that would correlate capacity for solute transport and suitability for sludge application (also valuable for onsite waste disposal or solid waste disposal);
- Research on subsurface injection of sludge and the relative probability of bacterial transport in groundwater; and
- Epidemiologic studies evaluating whether there is a correlation between bacterial infections (not necessarily disease) and bacterial aerosols.

Future modifications of the Pathogen Risk Assessment Model that may improve its accuracy include the following:

- The model should be changec consider runoff of pathogens fr unincorporated sludge when rainfall occurs in the first 24 hours.
- A transfer factor could be added to the model to allow for redistribution of pathogens from subsurface to surface soil when the field is plowed.
- For a better description of sludge use on public parks and golf courses, which are more likely to have ponds, it might be beneficial to add the option for existence of a pond onsite.
- The limits of Subroutine RAINS should be further characterized to establish operating boundaries for input variables.

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Norm Kowal *is the EPA Project Officer, (see below).*
The complete report, entitled "Preliminary Risk Assessment for Bacteria in Municipal Sewage Sludge Applied to Land," (Order No. PB92-126820/AS; Cost: $35.00, subject to change) will be available only from:

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