United States
Environmental Protection
Agency

Health Effects
Research Laboratory
Research Triangle Park NC 27711

Research and Development

EPA/600/S1-85/015 Aug. 1986

EPA

Project Summary

Health Effects of Land Application of Municipal Sludge

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The potential health effects arising from the land application of municipal sludge are examined, and an appraisal of these effects made. The agents, or pollutants, of concern from a health effects viewpoint are divided into the categories of pathogens and toxic substances. The pathogens include bacteria, viruses, protozoa, and helminths; the toxic substances include organics, trace elements, and nitrates.

For each agent of concern the types and levels commonly found in municipal wastewater and sludge are briefly reviewed. A discussion of the levels, behavior, and survival of the agent in the medium or route of potential human exposure, i.e., aerosols, surface soil and plants, subsurface soil and groundwater, and animals, follows as appropriate. Infective dose, risk of infection, and epidemiology are then briefly reviewed. Finally, some general conclusions are presented.

This Project Summary was developed by EPA's Health Effects Research Laboratory, Research Triangle Park, NC, 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

For centuries Western man has been conscious of the potential value of the application of human wastes to the land. Thus, von Liebig, in his 1863 work, "The Natural Laws of Husbandry" wrote:

> "Even the most ignorant peasant is quite aware that the rain falling upon his dung-heap washes away a great many silver dollars, and that it would be much more profitable to him to have on his fields what now poisons the air of his house and the streets of the village; but he looks on unconcerned and leaves matters to take their course, because they have always gone on in the same way."

In spite of von Liebig's pessimism, farmers in many areas of the world have been applying sewage sludge to agricultural land for centuries. The practice has continued for millennia in the Far East. Sewage sludge (or "municipal sludge") has characteristics that make it valuable as a fertilizer and a soil conditioner: it contains fair amounts of nitrogen, phosphorus, and micronutrients, and it increases soil friability, tilth, pore space, and water-holding capacity.

In the United States a mandate for the greater use of land application of both municipal wastewater and sludge has been provided by the Clean Water Act of 1977 (PL 95-217), Title II (Grants for Construction of Treatment Works), Section 201, which states that the:

> "Administrator shall encourage waste treatment management which results in the construction of revenue producing facilities providing for (1) the recycling of potential sewage pollutants through the production of agriculture, silviculture, or aquaculture products, or any combination thereof. . ."

The land application of wastewater (or "land treatment") has been discussed in previous reports; the land application of sludge is the subject of the present report.

Land application of sludge consists of the low-rate application (compared with a purely disposal operation) to agricultural, forest, or reclaimed land of municipal wastewater sludge which has been "stabilized" in some way, e.g., anaerobic digestion or composting. That land application of sludge is an important and probably growing practice in the U.S. is indicated by the results of a recent survey of 1008 publicly owned treatment works, accounting for over 2 million dry metric tons per day of sludge. The survey found 17% of the total sludge to be utilized in large scale food-chain landspreading, 12% in large scale nonfood-chain landspreading, and 21% in distribution and marketing systems (much of which probably ends up in gardens and lawns).

With the application to land of large volumes of wastewater and sludge, it is evident that considerable potential for adverse health effects exists. The major health concerns with land treatment of wastewater and land application of sludge are somewhat different. Thus, the potential exposure of humans through the routes of aerosols and groundwater is frequently emphasized with wastewater, and through the food chain with sludge. Nevertheless, the agents, or pollutants, of concern from a health effects viewpoint are almost the same in wastewater and sludge. These agents can be divided into the two broad categories of pathogens and toxic substances. The pathogens include bacteria (e.g., *Salmonella* and *Shigella*), viruses (i.e., enteroviruses, hepatitis virus, adenoviruses, rotaviruses, and Norwalk-like agents), protozoa (e.g., *Entamoeba* and *Giardia*), and the helminths (or worms, e.g., *Ascaris*, *Trichuris*, and *Toxocara*). The protozoa and helminths are often grouped together under the term, "parasites," although in reality all the pathogens are parasites. The toxic substances include organics, trace elements (or heavy metals, e.g., cadmium and lead), and nitrates. Nitrates are usually not viewed as "toxic" substances, but are here so considered because of their potential hematological effects when present in water supplies at high levels. These agents form the basis of the main sections of this report. The major health effects of these agents are listed in Figure 1.

For each agent of concern the types and levels commonly found in municipal sludge are briefly reviewed. A discussion of the levels, behavior, and survival of the agent in the medium or route of potential human exposure, i.e., aerosols, surface soil and plants, subsurface soil and groundwater, and animals, follows as appropriate. (Runoff to surface water is not considered, since it is assumed that this will be prevented in a well-managed sludge land application operation.) For the pathogens, infective dose, risk of infection, and epidemiology are then briefly reviewed.

General Conclusions

Types and Levels of Agents in Wastewater and Sludge

The types of levels in wastewater and sludge of most pathogens are fairly well understood, with the exception of viruses. Since only a fraction of the total viruses in wastewater and other environmental samples may actually be detected, the development of methods to recover and detect viruses needs to be continued. The occurrence of viruses in an environmental setting should probably be based on viral tests rather than bacterial indicators since failures in this indicator system have been reported.

The tremendous number of organic chemicals possibly present in sludge, together with their myriad health effects and poorly understood behavior in the environment, represent a potential for public health risk when the sludge is applied to agricultural land. Among the trace elements, probably only cadmium, under ordinary circumstances, is likely to be of health concern to human as a result of the land application of sludge, with the exposure being through food plants or organ meats. Minimizing of health risks can probably be accomplished by the monitoring of sludge composition, and the regulation of maximum concentrations and cumulative application of toxic substances in land-applied sludge. The complexity of the organics composition of sludges, however, might require the development and use of biological assays to screen for toxicity.

Aerosols

Because of the potential exposure to aerosolized bacteria, and possibly viruses, at land application sites, it would be prudent to limit public access to a sludge spray source, such as an active spray gun or tank truck. Human exposure to pathogenic protozoa or helminth eggs through aerosols is unlikely.

Surface Soil and Plants

The survival times of pathogens on soil and plants are summarized in Table 1. Since pathogens survive for a much longer time on soil than on plants, recommended waiting periods before harvest are based upon probable contamination with soil. However, what is a safe waiting period before crop harvest for human consumption is really an unsettled issue.

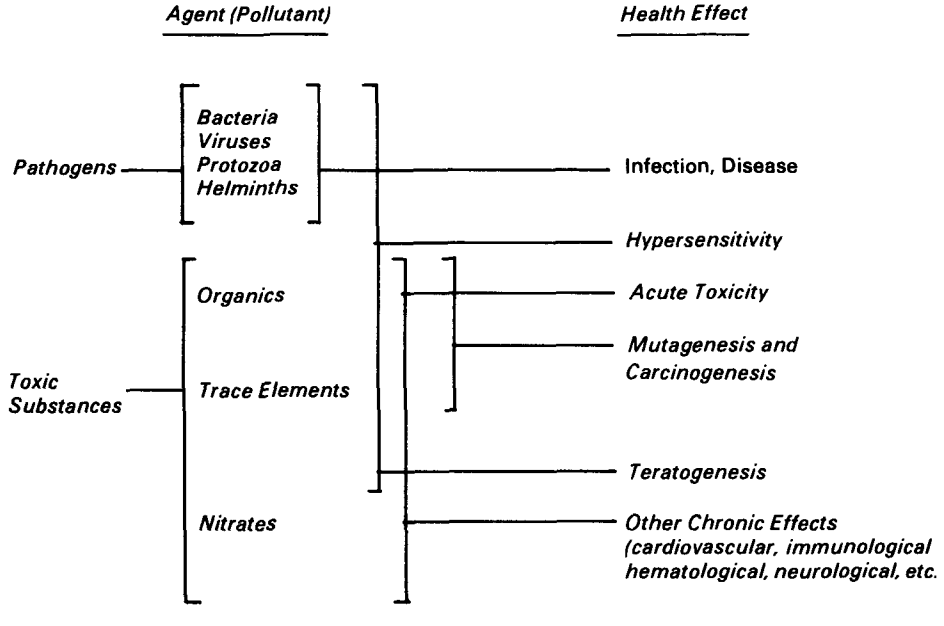

Figure 1. Health effects of pathogens and toxic substances.

Table 1. *Survival Times of Pathogens on Soil and Plants*

	Soil		Plants	
Pathogen	Absolute Maximum	Common Maximum	Absolute Maximum	Common Maximum
Bacteria	1 year	2 months	6 months	1 month
Viruses	6 months	3 months	2 months	1 month
Protozoa	10 days	2 days	5 days	2 days
Helminths	7 years	2 years	5 months	1 month

Aerial crops with little chance for contact with soil should probably not be harvested for human consumption for at least one month after the last sludge application; subsurface and low-growing crops for human consumption would probably require a six-month waiting period after last application. These waiting periods need not apply to the growth of crops for animal feed, however.

The levels of toxic organics likely to be present in soils at land application sites will probably result in very low levels in above-ground portions of plants, but levels in roots, tubers, and bulbs may present a health hazard.

The potential increase in cadmium levels in human food due to land application of sludge is still an unsettled question. Present levels of total dietary intake of cadmium for most people appear to be fairly safe. However, in view of human variability in sensitivity and the variability in food supply, these levels probably should not be allowed to rise greatly.

Movement in Soil and Groundwater

Properly designed sludge application sites may pose little threat of bacterial or viral contamination of groundwater. Human exposure to pathogenic protozoa or helminths through groundwater is unlikely. Groundwater is unlikely to represent a significant organic or trace element threat.

There is a possibility that land application of sludge may raise the nitrate concentration of groundwater above the drinking water standard of 10 mg/ℓ as N. This can be prevented, however, by proper siting and management practice, e.g., matching loading rate to crop uptake.

Animals

The literature to date suggests little danger of bacterial, viral, or protozoan disease to animals grazing at land application sites if grazing does not resume until four weeks after last application but the need for complete inactivation of helminths in sludge before land application is still unsettled. The feeding of land-application-site-grown plants to animals is unlikely to pose a health problem, but grazing animals may accumulate significant levels of toxic organics. The issue of accumulation of organics from the soil by plants and animals (particularly into milk), and into the human food supply, is poorly understood.

Infective Dose, Risk of Infection, Epidemiology

Because of the possibility of contracting an infection, it would be wise for humans to maintain a minimum amount of contact with an active land application site.

Epidemiological studies to date suggest little effect of land application on disease incidence. However, many questions on the public health consequences of land application of wastewater and sludge remain.

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The complete report, entitled "Health Effects of Land Application of Municipal Sludge," (Order No. PB 86-197 456/AS; Cost: $11.95, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
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