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Water Engineering
Research Laboratory
Cincinnati OH 45268

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Project Summary

Large Soil Absorption Systems for Wastewaters from Multiple-Home Developments

Robert L. Siegrist, Damann L. Anderson, and David L. Hargett

A study was conducted to evaluate community-scale soil absorption systems for treating and disposing of wastewaters. Included were a survey of current state attitudes and policies, an overview of a number of large soil absorption systems, and an in-depth analysis of one system. Study objectives were to assess the performance of existing large-scale absorption systems, to comment on the viability of presently used design methods, and to suggest improved approaches to design.

This Project Summary was developed by EPA's Water Engineering Research Laboratory, 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

Large subsurface soil absorption systems (LSAS's) for treatment and disposal of wastewater from subdivisions and small communities are becoming increasingly popular. These systems are being designed as permanent means of wastewater management, not as interim solutions to be used until conventional treatment technologies arrive.

The design and operation practices of large, multiple-home soil absorption systems appear simply to have evolved from the laboratory and field experience gained with small, single-home systems. However, the suitability of this practice remains in question without field experience involving community-scale systems. As the size of a subsurface soil absorption system increases to handle the wastewater from a small community, the design, construction, and management practices necessary to ensure acceptable performance become less clear.

Procedures

The objectives of this study were to investigate the performance of community-scale soil absorption systems, to identify potential deficiencies in presently used design criteria, and to develop recommendations regarding design and operation practices. More specifically, the project endeavored to accomplish the following:

1. To determine the current attitudes, policies, and level of use of community-scale subsurface wastewater absorption systems;
2. To investigate in detail the performance characteristics of the community wastewater absorption system at Westboro, Wisconsin; and
3. To characterize generally a number of multiple-home wastewater absorption systems in Washington.

This study was accomplished between June 1981 and December 1983 through the combined efforts of staff members from several organizations.

Conclusions

1. Design infiltration rates for long-term successful operation of LSAS's are not well defined.

2. Anaerobic conditions may predominate below LSAS's, even in sandy soils. Narrow, shallow trenches may be required to obtain aerobic environments.
3. *Septic tank effluent may load* LSAS's too heavily, requiring a higher degree of treatment to remove excess organics, suspended solids, etc., before LSAS treatment. Criteria for individual home wastewater systems are clearly inadequate for LSAS's.
4. Groundwater mounding may present a severe hindrance to proper wastewater treatment by the LSAS. Present methods of predicting the degree of groundwater mounding underestimated the actual conditions found.
5. Percolation testing as presently practiced was inadequate for LSAS design, and the use of vertical hydraulic conductivity curves for long-term acceptance rates was also in error.

Recommendations

Based on this study, the following recommendations are made for engineering LSAS systems:

Site Evaluation

1. Use professional soil scientists.
2. Inspect soil morphology to a depth of at least 2 m below the system bottom.
3. Allow at least 1.5 m of unsaturated soil below the system bottom.

Design

1. Flow should be based on design population.
2. Shallow trenches should be used instead of beds.
3. A minimum of three absorption systems should be used to permit resting cycles.
4. Infiltration rates should be conservative and based on entire site soil morphology and hydraulic capacity.

Installation

1. Installation should be accomplished as quickly as possible to minimize exposure of the infiltrative surface.
2. Construction machinery (either tired or tracked) travel over the infiltrative area should be prohibited, even if a thin layer of gravel or sand covers that surface.

Operation

Rotate systems between resting and dosing on an annual basis, avoiding cold weather rotation; or initiate system resting at the first sign of ponding.

Monitoring

1. Monitor LSAS influent flows at least monthly to determine loadings.
2. Characterize influent COD, TSS, NH_4, pH and grease initially and at least annually thereafter.
3. Inspect LSAS's for ponding and dosing at least monthly.
4. Monitor groundwater elevations at least quarterly.

The full report was submitted in partial fulfillment of Contract No. 68-03-3057 by Rural Systems Engineering, Inc., under the sponsorship of the U.S. Environmental Protection Agency.

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***James F. Kreissl** is the EPA Project Officer (see below).*
The complete report, entitled "Large Soil Absorption Systems for Wastewaters from Multiple-Home Developments," (Order No. PB 86-164 084/AS; Cost: $16.95, subject to change) will be available only from:
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Project Summary

Microbial Activity in Composting Municipal Sewage Sludge

J. Robie Vestal and Vicky L. McKinley

Research was conducted to identify the most important operational parameters that limit the growth and decomposition activity of composting sludge microbiota. Sensitive and nonselective biochemical methods of monitoring microbial biomass and activity were tested and used to study the interactions between the microbial communities and temperature, the primary factor affecting their activity during composting. Optimum temperatures for microbial activity and biomass were generally within the 35° to 55°C range. Biokinetic analyses revealed that compost samples from low-temperature (25° to 45°C) areas of the pile had much greater microbial activity (measured as the rate of incorporation or mineralization of (^{14}C) substrates) than did samples from high-temperature (60° to 75°C) areas. The microbial communities became better adapted to increasing temperatures as composting progressed, but their temperature optimum was never greater than 55°C. Biomass was monitored by measuring the lipid phosphate content (an important cell membrane component) of the compost. Other parameters that were measured included the moisture content, total organic content, total protein content, and pH.

This Project Summary was developed by EPA's Water Engineering Research Laboratory, 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

Large aggregations of organic-rich matter have long been known to heat up and become increasingly humified over extended periods. These effects are brought about by the activity of the indigenous microbial community, which decomposes the usable matter for energy and growth substrates, producing metabolic heat as a byproduct. In organic piles of sufficient size and insulation, this metabolic heat is trapped and can elevate the temperatures within the pile to in excess of 80 °C within a few days. The production of composted material through this process has been a means of recycling organic waste products throughout much of history. Recently the process has become an important means of disposing of municipal solid waste and sewage sludge. The primary goals of composting in solid waste management are to rapidly reduce the pathogens, odors, putrescible organic matter, moisture, and bulk, and to produce a biologically stabilized material.

No general agreement has yet been reached on the best conditions and procedures for optimizing the efficiency of decomposition (stabilization) during the composting process, so a wide variety of methods are currently practiced. However, temperature is generally agreed to be the most critical parameter influencing the rate of composting and the quality of the product, given reasonable initial environmental conditions of moisture, free air space, pH and nutrients, and provided that oxygen does not become generally limiting.

Many of the findings on optimum temperatures for maximum decomposition rate during composting have been in conflict. These discrepancies may be partly due to the indirect and incomplete nature of many of the studies concerning microbial activity and biomass in composting material. Direct comparisons of decomposition rate between different temperature regimes require experimental arrangements unrelated to the practice of composting and produce unrealistic results. Estimates of microbial decomposition in composting material have typically been made using such indirect indices as the overall temperature of the composting pile, odors, moisture content, carbon dioxide evolution from the composting pile, or oxygen uptake by the compostion pile. In most cases, concurrent assessments of microbial biomass were not made, or they were aimed only at quantifying the numbers of surviving pathogens or other specific groups using selective isolation techniques.

The purpose of this study was to provide a better understanding of the factors influencing the microbial activities in composting sewage sludge. The activity and biomass of the microbial community as a whole were accurately and consistently measured to permit conclusions to be made about an optimal temperature range for rapid decomposition during composting. Basic information leading to a better understanding of rapid thermogenic microbial successions was also obtained.

Results and Discussion

Composting was done in a full-sized commercial composting bin using forced aeration to regulate the overall temperatures of the piles. Each batch composting run lasted approximately 2.5 weeks, during which the material was removed and turned once or twice.

The microbiota of composting municipal sewage sludge from Columbus or Akron, Ohio, was analyzed during 10 different composting runs. A temperature gradient existed within the composting piles, with the central areas near the surface of the piles being the hottest. On each sampling day, samples were taken from several different areas, each with a different sampling temperature. In every case, a decrease in microbial activity occurred as temperature increased, with overall optimum temperatures falling between 35 ° and 55 °C. Microbial activity was measured as the hourly rate of (^{14}C) acetate incorporation into microbial lipids per μmol of lipid phosphate biomass. The changes in this microbial activity rate in response to compost sampling temperatures during run No. 6 (see Figure 1) are typical. Microbial biomass also decreased with increasing temperature in most of the compostiñg runs. The biomass data from run No. 6 (Figure 2) are typical. The same

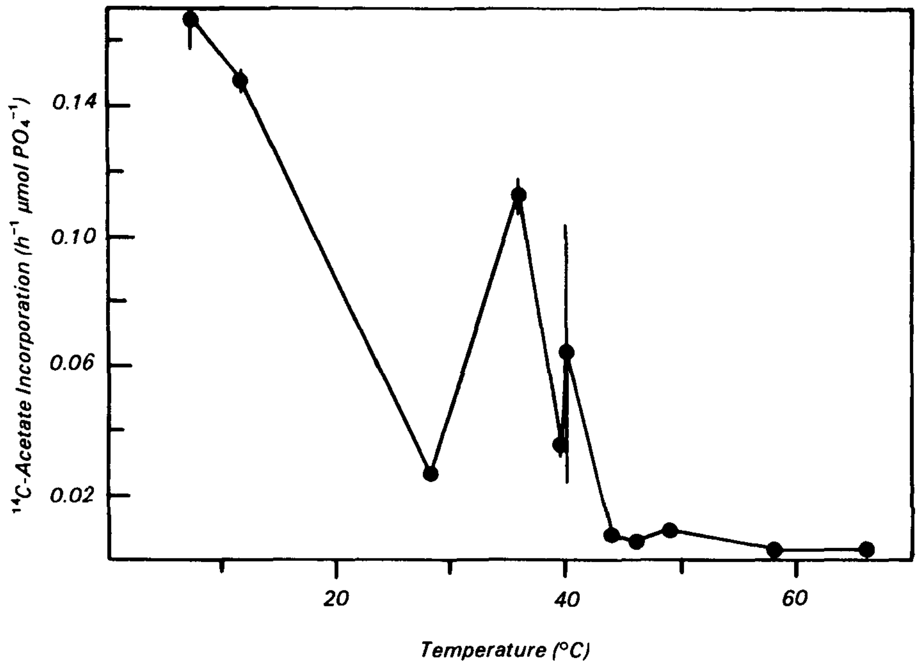

Figure 1. *Microbial activity, measured as the rate of (^{14}C) acetate incorporation into lipids pe hour per μmol of lipid phosphate biomass x1O^{-1}, of pooled sewage sludge compos samples in response to the mean sampling temperature of the pooled sample during composting run No. 6. Sampling days are indicated by the number associated with the data points. Activity values are the mean ± one standar deviation of three replicates.*

trends in microbial activity were found for all of the substrates tested ((^{14}C) acetate, glucose, and glutamate), and the results were similar whether the data were expressed in terms of biomass (per μmol of lipid phosphate biomass) or in terms of the amounts of compost (per gram of dry compost).

Of all the physical and chemical paramters measured during this study, temperature had the most dramatic and consistent effects on microbial biomass and activity. Microbial activity and biomass also correlated with the pH of the compost, indicating that pH may be an indirect indicator of microbial activity. The typical increases in pH during composting are primarily a result of microbial activity, and in addition, the microbiota may be more active at the neutral-to-slightly alkaline pH values found later in the runs. This hypothesis was not tested directly during this study, however.

During four of the composting runs, each composting pile was divided into a low-temperature section (mean pile temperature $\leq$ 55 ° to 60 °C) and a high-temperature section (mean pile temperatures up to 70 °C). Microbial activit and biomass were higher in the low temperature section, even when sample: taken from the high-temperature sectio came from the same samplin temperature.

An experiment was designed to deter mine the optimum temperatures for th activities of the microbial communitie: from various temperature zones in th composting pile. Activities in samples fron low-temperature areas (25 ° to 50 °C) o the pile were almost always much highe than those in samples from high temperature areas (60 ° to 75 °C), regard less of the assay's incubation temperature When incubated at different temperature: during the incorporation assay, th samples from low-temperature areas o the pile exhibited optimum thermal activit at 30 ° to 55 °C. Not only did samples fron high-temperature areas have much lowe levels of activity, many did not respond a all to varied incubation temperatures, in dicating that the microbial population: were probably very debilitated. As com posting progressed, the optimun temperatures increased somewhat, in

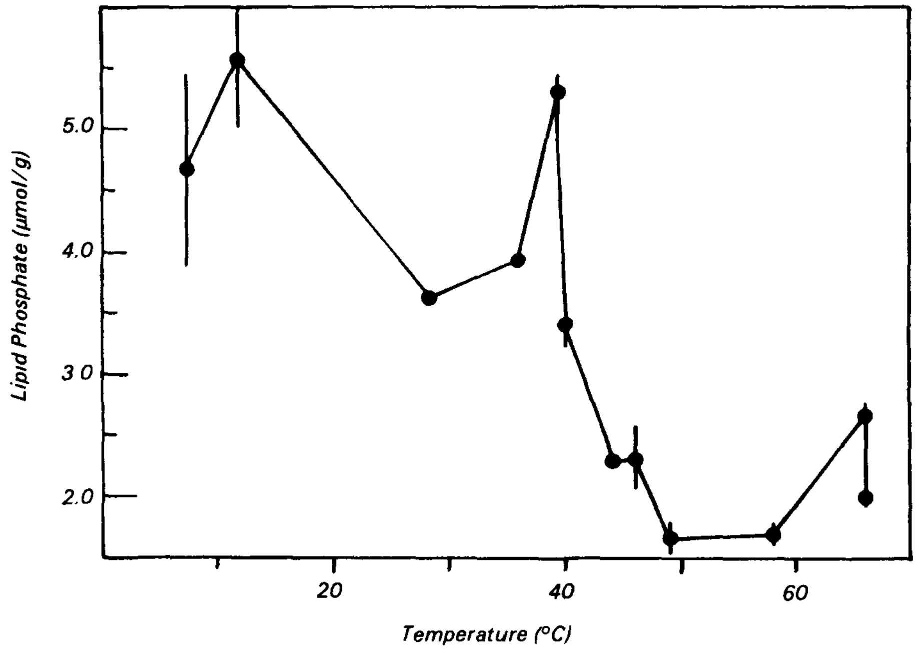

Figure 2. *Microbial biomass, measured as the lipid phosphate concentration, of pooled sewage sludge compost samples in response to the mean sampling temperature of the pooled samples during composting run No. 6. Sampling days are indicated by the numbers associated with the data points. Biomass values are the mean ± one standard deviation (n=3).*

dicating that the microbial communities were adapting to the higher temperatures. Nonetheless, optimum temperatures of the communities never exceeded about 55 °C, even in the samples from the high-temperature areas.

Conclusions and Recommendations

The major conclusions of this study include the following:

1. The optimum temperature range for composting sewage sludge in a forced-aeration batch, static-pile system appears to be 35 ° or 45 ° to 55 °C. The lower limits of this range are much less distinct than the upper limits. These conclusions are based on measurements of the levels of microbial activity (rates of (^{14}C) substrate incorporation or mineralization) and biomass (lipid phosphate concentration). Microbial activity and biomass dropped off very rapidly as composting temperatures exceeded 55 °C. Other indirect and much less responsive indicators of microbial activity and biomass (such as the compost pH and protein concentrations) were also maximized within this temperature range. The minimum levels of microbial activity were always found in compost samples at very high temperatures (> 60 °C).
2. As composting progressed, evidence showed that the microbiota were adapting to higher temperatures, but no microbial communities acclimated to temperatures above 55 °C. No evidence indicated that extremely thermophilic organisms (those with optimum temperatures above 60 °C) played a measurable role in composting.
3. Compared with piles composted simultaneously at 60 ° to 85 °C, piles aerated to maintain temperatures at or below about 55 °C showed significant improvements in the rates of microbial metabolism and growth.

The recommendations that naturally follow from these conclustions include the following:

1. Composting should be done at temperatures within the stated optimum range whenever possible.
2. Nonselective, responsive, and sensitive methods for analyzing microbial activity and biomass should be used to monitor the process when necessary.

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The complete report, entitled "Microbial Activity in Composting Municipal Sewage Sludge," (Order No. PB 86-166 014/AS; Cost: $16.95, subject to change) will be available only from:
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