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Project Summary

Design and Management of Subsurface Soil Absorption Systems

E. Jerry Tyler, William C. Boyle, James C. Converse, Robert L. Siegrist, David L. Hargett, and Mark R. Schoenemann

This report presents the results of continuing research regarding onsite wastewater disposal by the Small Scale Waste Management Project (SSWMP) at the University of Wisconsin-Madison. Reported here are the results of two separate investigations: (1) a study of how construction practices affect the hydraulic properties of soil absorption systems, and (2) a field study of how various operational strategies affect the soil infiltration properties of soil absorption systems.

The investigation of construction practices showed that construction machinery traffic can significantly reduce the porosity and infiltration rate of a soil absorption bed. The degree of damage varies with soil texture, structure, and moisture content. Wet soils are particularly vulnerable. Field trials demonstrated that a damaged absorption bed can be restored by removal of the compacted and sheared layers. However, the better approach is to prevent unnecessary compacting of the absorption bed area, especially that resulting from construction machinery traffic.

The study of operational strategies for soil absorption systems consisted of three separate experiments: (1) comparison of the conventional method of applying septic tank effluent (simulated trickle) with once-daily, uniform applications, (2) comparison of alternating periods of effluent loading and resting with continuous conventional application, and (3) comparison of the in-house segregation of greywater with the application of greywater, combined wastewater, and tapwater control. All three experiments used three effluent loading rates, including the basic design loading rate of 2 cm/day, as well as 4 cm/day and 8 cm/day. The three experiments were implemented on soils with similar hydraulic properties and used wastewaters from typical, rural, single-family homes. Soil absorption cells were used *in situ* to simulate the conventional application of effluent. At each site, three replica cells were constructed for each treatment.

During the first year of the experiment comparing conventional and once-daily, uniform applications, soil infiltration rates decreased significantly for all treatments and loading rates, suggesting the progressive development of a biological clogging layer that impedes flow.

In addition, the infiltration rate decreased most strongly for the conventional treatments, with the greatest decrease occurring in cells with higher loading rates. All once-daily uniform treatments showed higher infiltration rates than the conventional treatments, regardless of loading rate. These preliminary results imply that larger, less frequent doses of septic tank effluent are superior to the conventional trickle application for maintaining hydraulic properties that allow adequate absorption.

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

Wastewater disposal systems composed of a septic tank and a soil absorption field serve about one-fourth of U.S. households, mostly in rural and suburban areas. Failures of these systems have frequently been traced to installations in soils with inadequate natural drainage or hydraulic conductivity (permeability). Better site selection and system design criteria are reducing the frequency of these failures, but additional factors seem to be involved in many cases. This report examines how two such factors—construction practices and operating strategies—can affect the hydraulic and infiltration properties of soil absorption systems.

Construction Practices

Some workers have suggested that alteration of soil structure by construction machinery during system installation may be a major cause of system failures on otherwise suitable sites, particularly those failures that occur during the first year of system operation. However, the link between construction compaction and system failure has not been documented. Cautions and recommendations for system construction have been published, but they lack substantiating evidence. Some authors have suggested ways to avoid compaction and smearing during system construction, but these suggestions are supported only by sketchy data in the form of approximate infiltration rates for uncrusted and puddled soils of sandy loam, silt loam, and clay texture. Furthermore, the experimental procedures are not detailed.

The literature was reviewed in the areas of soil science and civil and agricultural engineering to provide any comparable information on the potential effects of construction techniques and equipment on the performance of soil absorption systems.

Two soils of different textures were selected for field trials. The Plano silt loam (a fine-silty, mixed, mesic Typic Argiudoll) was chosen to represent soils covering large areas of southern and western Wisconsin. These soils are suited for soil absorption systems but they have enough clay to make them susceptible to damage during construction.

The Ontonagon silty clay loam (a very fine, mixed Glossic Eutroboralf) had a clayey texture and represents soils occurring over much of eastern Wisconsin and some areas of the northern and north-central parts of the state. These soils are at best marginal in their suitability of subsurface soil absorption systems, and their high clay contents make them very susceptible to construction damage.

In each soil, investigations were carried out in the Bt horizon, since the accumulated clay in this zone increased the risk of construction damage. Each soil was tested at a moisture content near the plastic limit, which is close to the water content of most efficient compaction for the ranges of compactive effort studied. Since dry soils should be much less subject to compaction, each soil was also tested at a moisture level far below the plastic limit.

Modified Operating Strategies

The two major objectives of this phase of the investigation were:

(1) to evaluate the effects of the effluent application method on soil infiltration rates, and

(2) to evaluate the effects of in-house wastewater segregation on soil infiltration rates.

Two distinct methods of wastewater application were evaluated under the first objective: (a) Once-daily uniform application versus conventional application (trickle flow), and (b) alternating periods of waste application and resting versus continuous application. The second objective was evaluated by comparing greywater septic tank effluent with combined wastewater septic tank effluent; both were applied conventionally.

Carefully controlled experimental designs and procedures were developed. These procedures assumed that (1) column studies have not proved adequate to establish the size of soil absorption fields; (2) establishment of loading rates on any soil group requires experiments using a variety of loading rates, including those that cause failure; and (3) the same soil and wastewater resources should be used to investigate a particular management scheme so that variations in the study can be attributed to that management scheme. To this end, field studies were designed using extensively monitored soil absorption cells at three field sites where soil conditions were similar. Three wastewater loading rates were selected, ranging from conventional loading to four times conventional values.

A major goal in each of these experiments was to monitor the effects of the operational strategies and application rates on the dynamics of soil field failure as measured by soil permeability and soil moisture regime. All cells were therefore monitored to evaluate infiltration rates, soil moisture potential (tensiometry), and cell ponding.

Conclusions

Construction Practices

1. No chemical stabilization agents can increase soil strength enough to prevent damage during construction of soil absorption systems.
2. Work should be scheduled to avoid rainfall.
3. The type of bucket used had a pronounced effect on observable smearing. A smooth-edged bucket created a smeared surface of 2- to 6-cm-wide plates over the whole bed. The tooth-edged bucket left smear marks only where the teeth came in contact with the soil.
4. The number of large pores was reduced in the smooth, slick areas left by both types of backhoe buckets and wheel traffic compaction. The pores that remained in these areas tended to be aligned horizontally.
5. Wheel traffic reduced infiltration rates in all cases but the dry, strongly structured, silty clay-loam soil. In the trials where the infiltration rate was reduced, an increase in the amount of traffic corresponded with even greater decreases in the soil's infiltration rate.
6. When the disturbed surface was removed, infiltration rates returned to approximately the same rate as for undisturbed soil. The depth of removal necessary to return to the former infiltration rate increased with increased wheel traffic.
7. The weaker soil structure of the dry silt loam resulted in its being crushed more readily by machinery than the more strongly structured dry silty clay loam.
8. The following recommendations are based on the above conclusions:
   a. All traffic should be kept out of the bed;
   b. A tooth-edged backhoe bucket should be used for soil absorption system construction;

c. Work should be done only when the soil is dry.

Modified Operating Strategies

Based on the experience to date with the modified absorption system experiments (particularly the extended period of operation at Site 1), the following conclusions can be advanced with regard to alternative management strategies for onsite systems. Because of the current ongoing status of these experiments, results and conclusions presented here should be regarded as preliminary. The original project objectives can be met only through continued, intensive monitoring of these experiments by the methods described in the full report and by newly refined and applied techniques.

1. All experimental cells appear to be developing biological clogging layers with cumulative effluent application, but the rates vary, as indicated by declining infiltration rates with time and soil moisture tension measurements.
2. Decline of infiltration rate (or effluent absorption capacity) is very strongly linked to the frequency and amounts of effluent application.
   (a) Conventional (simulated trickle) application of effluent causes a faster and more complete decline in infiltration rate than effluent applied in a once-daily dose.
   (b) Increasing the daily effluent loading rate in conventional systems contributes to the steady decline of infiltration rate over the life of the system.
   (c) Increasing the effluent loading rate in systems using the once-daily dosing method does not yet appear to affect the infiltration rate strongly over time.
3. Findings to date suggest that once-daily dosing of the effluent load appears to be superior to the conventional trickle application approach in terms of maintaining the hydraulic properties of the soil system. However, this project has thus far considered only the hydraulic loading concern and has not addressed the issue of whether increased hydraulic loading of effluent by dosing and higher application rates assures an acceptable level of effluent treatment.
4. Application of both greywater and total waste to two parallel soil absorption fields in a silt loam soil is under way, but it would be premature to draw any conclusions about the relative rates of clogging of these two systems.

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E. Jerry Tyler, William C. Boyle, James C. Converse, Robert L. Siegrist, David L. Hargett, and Mark R. Schoenemann are with the University of Wisconsin, Madison, WI 53706.

***James F. Kreissl** is the EPA Project Officer (see below).*

The complete report, entitled "Design and Management of Subsurface Soil Absorption Systems," (Order No. PB 85-216 570/AS; Cost: $16.00, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

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U.S. Environmental Protection Agency
Cincinnati, OH 45268

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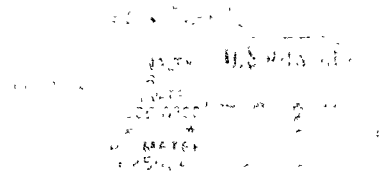

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