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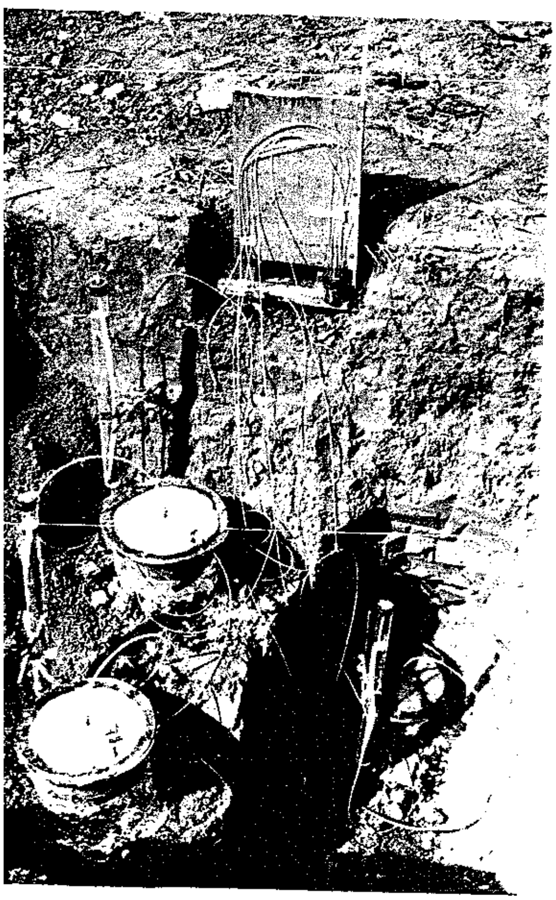
septic tanks now possible on nearly all soil types



The crust test, used to measure the permeability of saturated and unsaturated soil.

BY J. BOUMA

THE USE OF septic tanks became widely accepted in this country during the suburban housing boom after the Second World War. As of 1971 an estimated 13 million systems were in use, serving as many as 50 million persons. Their use is increasing at a rate of about half a million new units per year.

The evaluation of system performances in different soils varies widely, partly because of lack of objective monitoring data and of well defined performance criteria. However, system failure evidenced by either surface seepage of unpurified effluent or by ground water pollution, occurs frequently and most notably in certain types of soil.

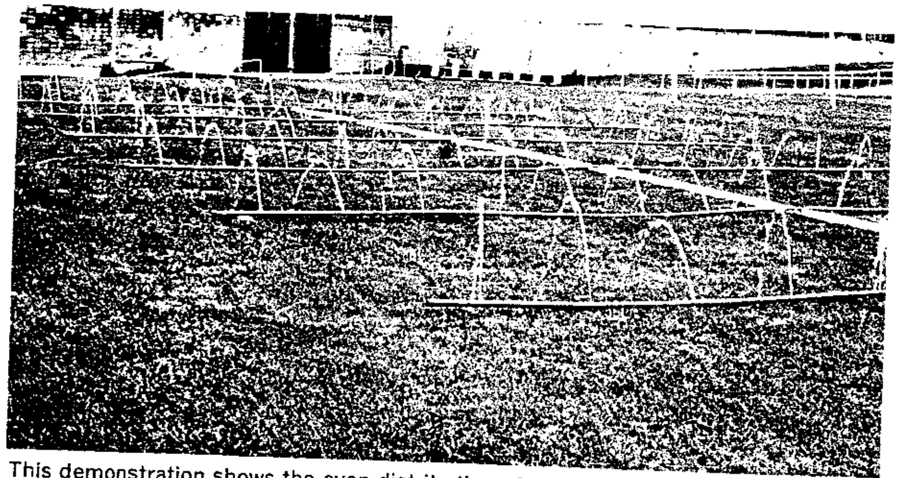
Currently, health codes are in effect that restrict use of soil absorption systems to sufficiently permeable, well drained "suitable" soils with minimum bedrock or groundwater levels at least 3 feet below the bottom of the seepage system. These codes have proved to be very useful, but systems constructed in "suitable" soils still can malfunction frequently. And the exclusion for development of at least half of all soils, classified as "unsuitable", creates many problems.

Our interdisciplinary Small Scale Waste Management Project at the University of Wisconsin was established to study these problems in 1971 with funding by the State of Wisconsin, the Upper Great Lakes Regional Commission, and the EPA (since 1973). This paper will only discuss research relating to use of soils or soil materials for absorption and purification of effluent.

Soil potential

The septic tank provides anaerobic treatment but the effluent has a high pollution potential because of its pathogenic bacteria and viruses and high concentrations of suspended solids, biological oxygen demand (BOD), nitrogen, and phosphorus.

The soil absorption field is the most crucial part of the system. Purification must be achieved by means of adequate infiltration into and percolation through the soil.



This demonstration shows the even distribution of effluent when the innovative pressure system is used. The holes would not be pointed upward when the system was installed underground.

Column studies and field monitoring data have proved that soil can be very effective in removing pollutants from effluent, but only if the soil is not overloaded.

Exact determinations of the capacity of soils to accept and conduct liquid have to be made, therefore. Currently used tests, such as the percolation test, are not suitable because of their empirical nature and variability. New tests, such as the crust test, were developed to determine hydraulic properties of soils more accurately. These tests are now widely applied to Wisconsin soils and results are applied to size systems adequately.

In addition, modern soil physical techniques, such as tensiometry, are applied to soil adjacent to seepage systems in the field to determine performance characteristics, thus avoiding sometimes misleading test results obtained from laboratory column studies.

We found an impressive potential of virtually all soils not only to accept and conduct liquid waste when properly loaded, but also to purify it during percolation. This formed a good starting point for the design of innovative systems for different soil conditions. Rather than have one system for a limited number of soils, different systems could be designed for a wider range of different types of soils.

Innovative systems

Infiltration and purification of effluent can be very much improved in many soils by applying the effluent intermittently once a day, rather than as a continuous trickle as in the traditional system. In addition, an even distribution over the entire seepage area during each dosage should be achieved to avoid local overloading which may result in relatively high flow rates in the soil and associated poor purification, or in early development of soil clogging due to bacterial action which strongly reduces infiltration rates into the soil. All our experimental systems therefore use a newly developed pressure-distribution system for effluent application.

Adequate infiltration is achieved when the loading rate does not exceed the long-range capacity of soils to accept effluent. On-site measurements around operating, well-performing seepage systems in different soils have provided data from which maximum allowable flow rates were derived for different types of soil. These rates, which are used to define required minimum seepage areas, are relatively low because biological clogging of soils reduces initially high infiltration rates.

A particular problem occurs in clayey soils where infiltrative surfaces can easily be compacted during construction under wet conditions, resulting in unacceptably low infiltration rates. Construction of a series of shallow trenches, built under rather dry soil conditions, can avoid these problems.

Adequate sizing and good system management in terms of techniques of effluent application, as discussed, can result in satisfactory disposal and adequate purification in many soils. However, the latter still may be inadequate under certain conditions. For example, additional soil is needed to purify the effluent in shallow, permeable soils over very permeable creviced bedrock which does not provide filtration. So we designed mound systems consisting of a covered seepage bed on top of 2 feet of sand-fill deposited on top of the original soil surface. Monitoring shows adequate purification at the bedrock level.

Inadequate purification may also occur in soils with high groundwater tables occurring either continuously or seasonally; the latter occurs generally in slowly permeable clayey soils. Purification processes in saturated soil are less effective than those in unsaturated soil. Two types of systems are being tested to overcome these limiting conditions. First, the seepage system can be raised above the soil in a mound system. The seepage system in these mounds consists of one or more narrow trenches, rather than seepage beds as in mounds over creviced bedrock, to avoid excessive rise of the water table below the mound. These mound systems are performing well. Our initial concern about freezing problems in the winter have proved to be unfounded. The alternative procedure is to drain the soils by either curtain drains, intercepting rain water moving laterally towards the system, or by other drainage systems that lower the water table well below the seepage trenches.

All innovative disposal systems

rely on and are designed on the basis of soil infiltration. Evapotranspiration can remove significant quantities of liquid in the growing season but *not* in the wintertime under Midwestern conditions.

Implications

The potential availability of satisfactory systems for on-site disposal of septic tank effluent in soils considered unsuitable for conventional systems has major implications for land use patterns. Zoning regulations may be necessary to avoid development of some of these areas. Soil maps should play an important role in this process by defining areas that can and cannot be used for innovative technology.

Another important function of soils maps is their use for extrapolation of data obtained with experimental systems at certain sites, to other sites with identical soils. This extrapolation procedure, which may require on-site soil classifications to avoid possible mistakes due to inclusions in soil map units when using soil maps only, can be helpful to reduce extensive on-site testing that could be necessary if no other means were available to compare different soils.

Finally, a general point of concern is the quality level of construction and the degree of concern of the homeowner. Innovative systems are more complex than the conventional systems and errors made during construction, or neglect by the homeowner can lead to system failures, whatever the merit of the design. Educational programs should therefore be a critical part of the entire technical program. □

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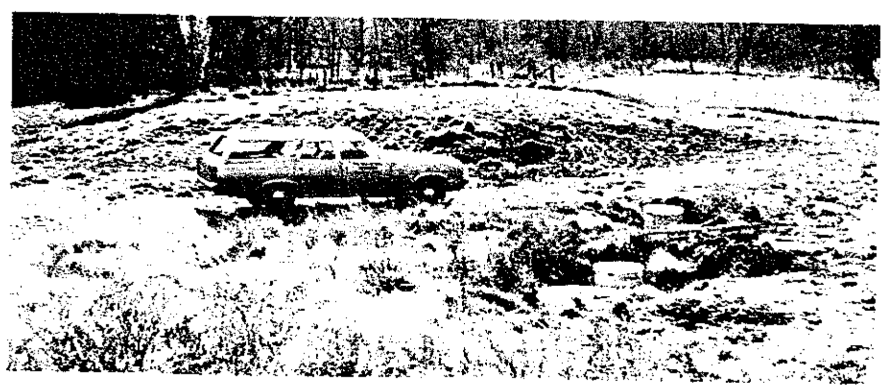
Mound system for disposal of effluent in shallow soils with highly permeable creviced bedrock. Effluent dosing is daily.

For slowly permeable soil, several shallow, gravel-filled ditches are constructed when the soil is dry. This is shown before backfilling.



For high groundwater tables, this is the mound system that is used. A series of narrow seepage trenches inside the mound receive the daily dosage of effluent.