#6.13

SMALL SCALE WASTE MANAGEMENT PROJECT

VIRUSES AND ON-SITE WASTEWATER TREATMENT

by

Dean Cliver

UNIVERSITY OF WISCONSIN - MADISON
College of Agricultural & Life Sciences
Biological Systems Engineering
Food Research Institute
Soil Science
School of Natural Resources
Environmental Resources Center
College of Engineering
Civil & Environmental Engineering

Copies and a publication list are available at:
Small Scale Waste Management Project, 345 King Hall
University of Wisconsin - Madison, 53706 (608) 265 6595 and at
http://www.wisc.edu/sswmp/

VIRUSES AND SEPTIC TANK EFFLUENT

Dean Cliver

PREFACE

The Small Scale Waste Management Project developed in response to the need for safe, reliable and economic alternative treatment and disposal systems for small wastewater flows in unsewered areas.

The Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension, has been working on the problem since 1969, with initial support from the Wisconsin Department of Natural Resources. The Upper Great Lakes Regional Commission also provided funding to the University-Extension. Special research funds were appropriated by the State of Wisconsin in November, 1971 to the College of Agricultural and Life Sciences, University of Wisconsin-Madison to develop solutions to the problem. Additional funds were granted to the Water Resources Center, University of Wisconsin-Madison by the Environmental Protection Agency.

PARTICIPATING GROUPS

UNIVERSITY OF WISCONSIN-MADISON

College of Agricultural and Life Sciences
- School of Natural Resources
- Center for Resource Policy Studies
- Departments of: Soil Science, Food Research Institute, Bacteriology, Agricultural Engineering, and Agricultural Economics

College of Engineering
- Sanitary Engineering Laboratories

Graduate School
- Water Resources Center

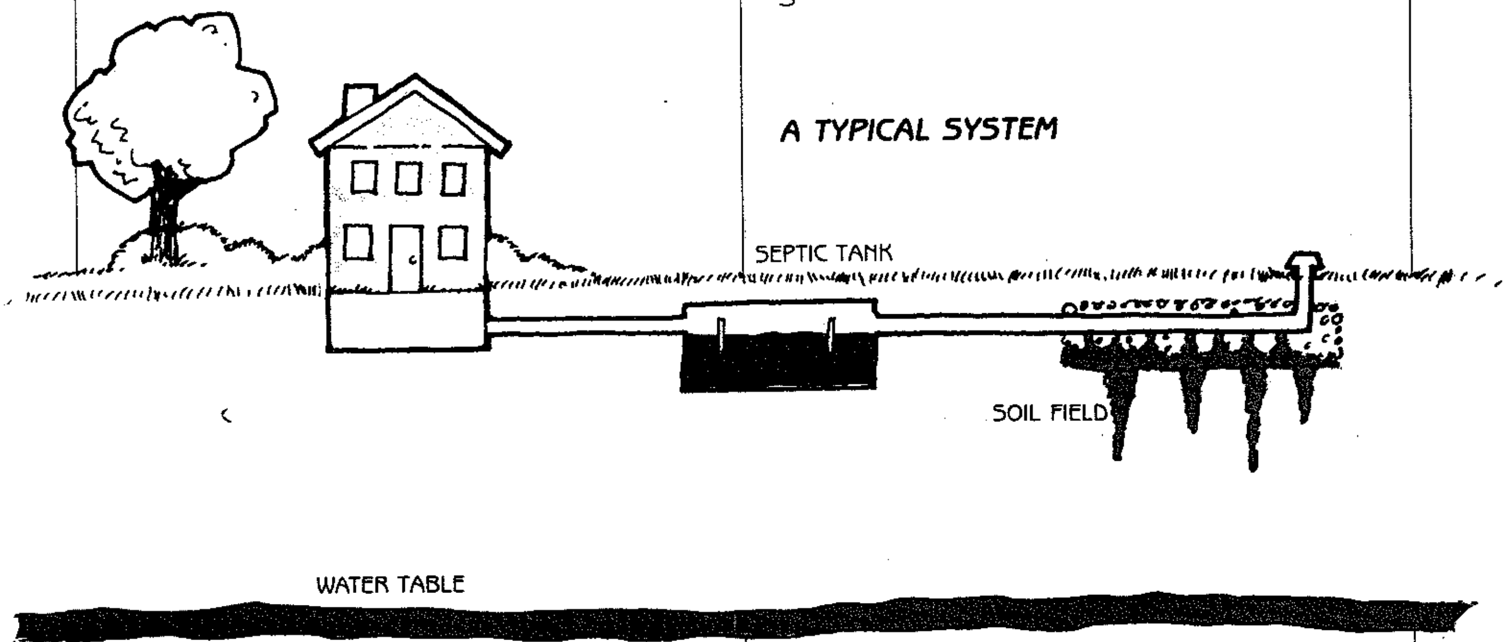
UNIVERSITY OF WISCONSIN-EXTENSION

Division of Economic and Environmental Development
- Environmental Resources Unit
- Geological and Natural History Survey

ON-SITE TREATMENT OF WASTEWATER

Homes and other buildings that are not connected to urban sewer systems must have on-site wastewater treatment systems. About 50 million people are served by about 15 million on-site systems in the United States, and there appears to be a trend toward greater use of on-site treatment in the future.

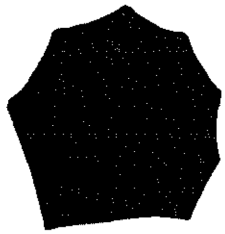
A TYPICAL SYSTEM

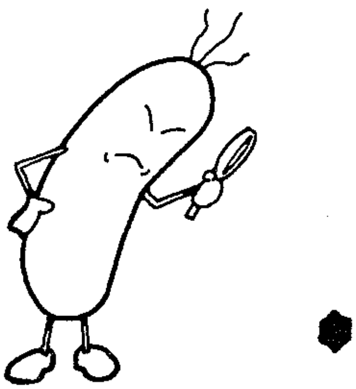


Because viruses pose a threat to public health, research in the Small Scale Waste Management Project at the University of Wisconsin is looking at the fate of viruses in on-site wastewater treatment systems. To understand the RESULTS, it is important to understand viruses.

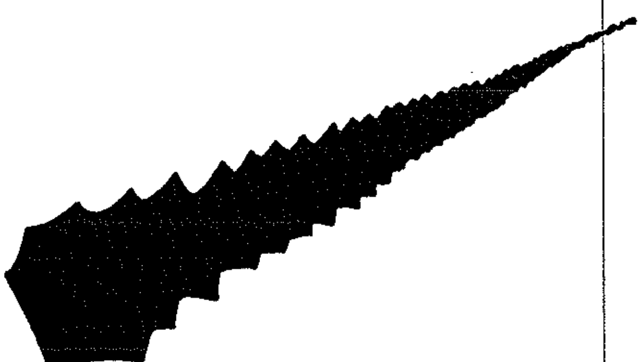
WHAT ARE VIRUSES?

VIRUSES are *not* nice!

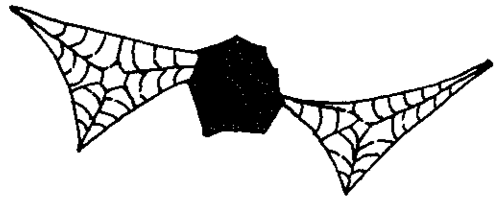




They are so much smaller than BACTERIA that they can't be seen with a light microscope.

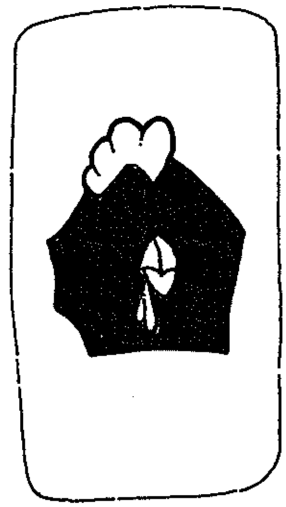


A million in a row would only stretch an inch.



When not in someone's body they're quite INERT.

Viruses are SPECIFIC in causing INFECTIONS AND DISEASE.

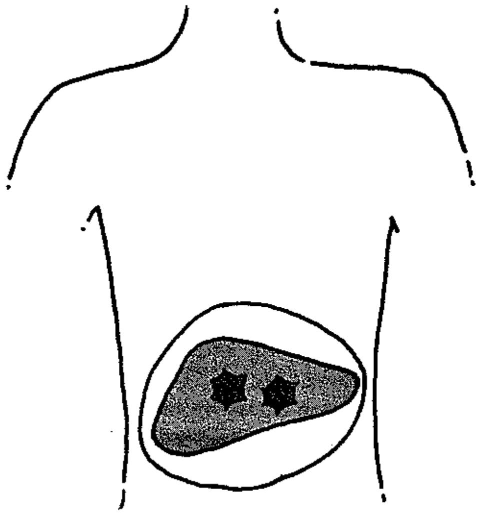


There are chicken viruses

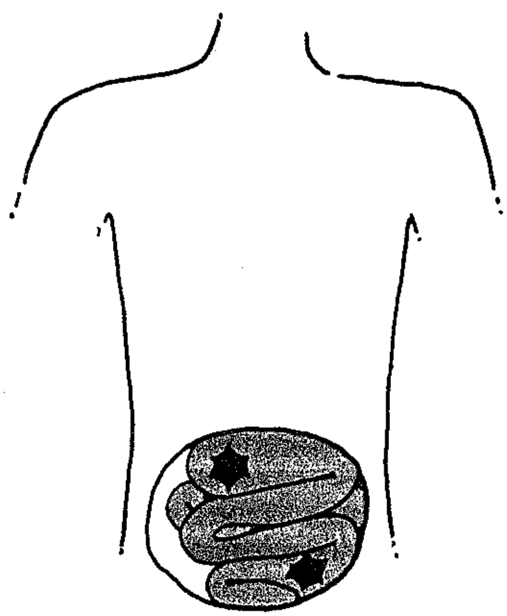
and pig viruses

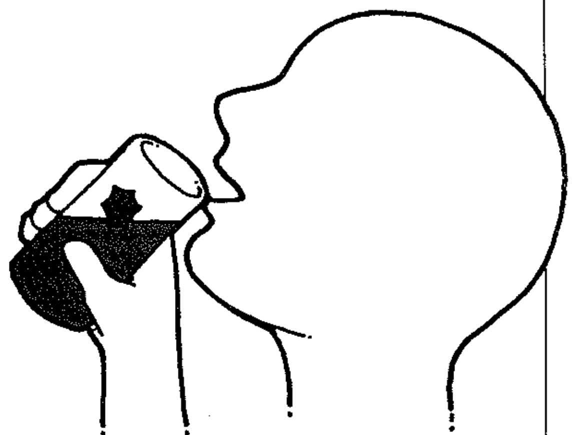
and many others that don't ordinarily infect people.

Among viruses that do infect people, many are specific for certain parts of the BODY. The viruses most pertinent to on-site wastewater treatment infect the liver and cause hepatitis,



or infect the lining of the intestine and cause gastroenteritis (vomiting and diarrhea).



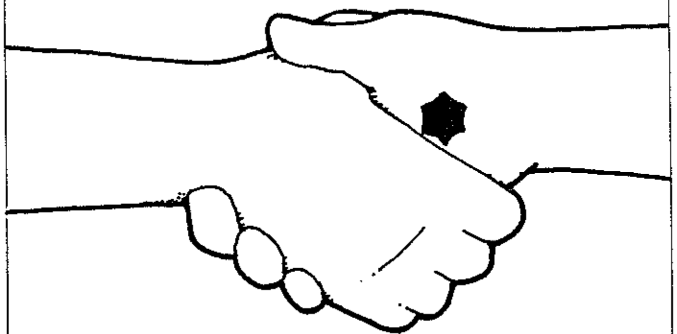


These and many other INTESTINAL viruses are produced in the small intestine and shed in feces; they infect if swallowed.

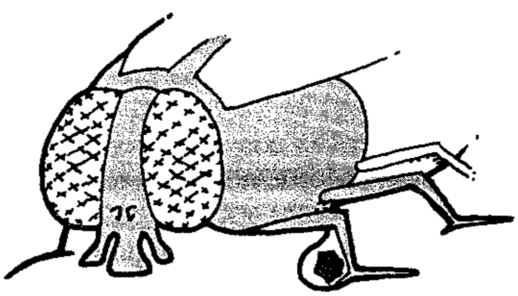
Because the hepatitis and gastroenteritis viruses do not replicate in laboratory cultures satisfactorily, laboratory and field research concerning on-site wastewater treatment has been performed using intestinal viruses that resemble these more dangerous agents but can be measured more readily in the laboratory.

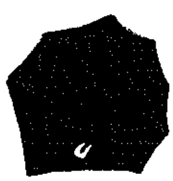
How are intestinal viruses SPREAD?

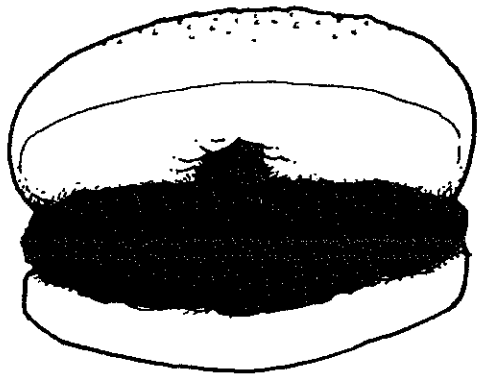
They may be passed DIRECTLY from person to person by TOUCH.



They may also be transmitted indirectly by VECTORS, such as flies,

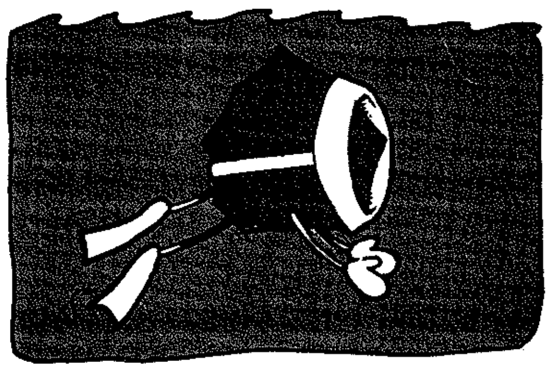


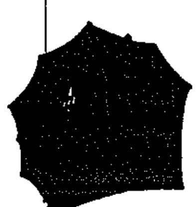




or by VEHICLES, such as food . . .

. . . or water.

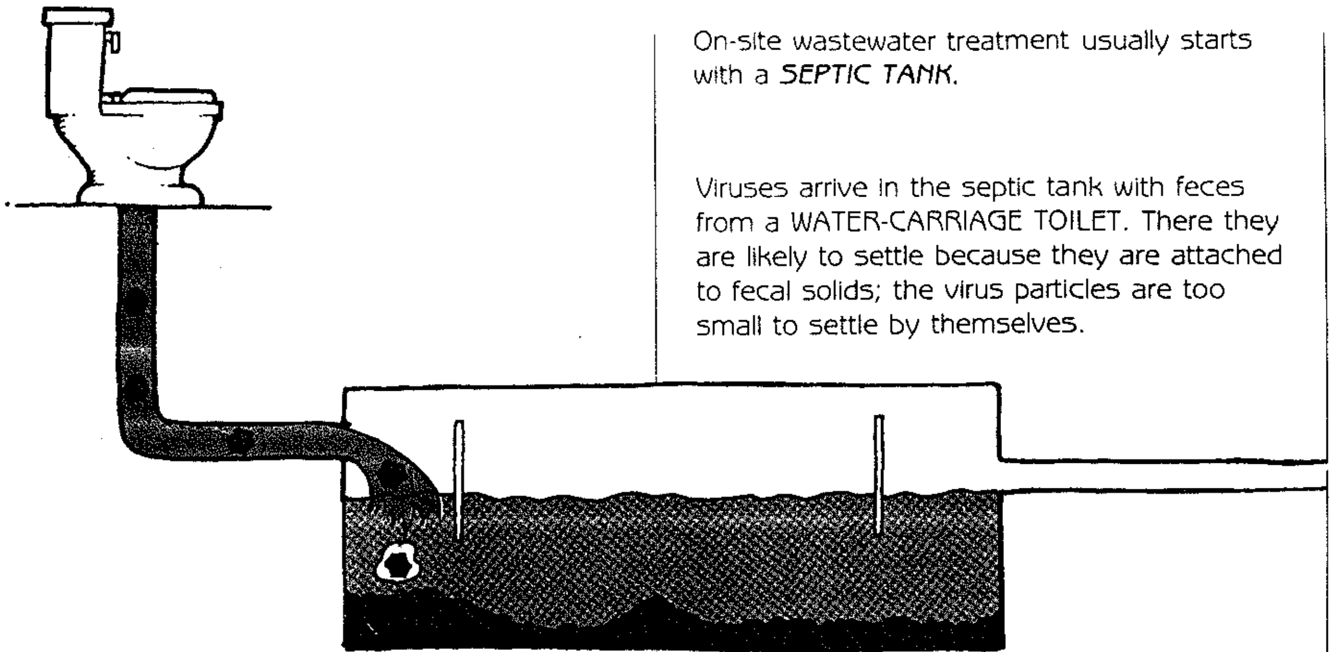




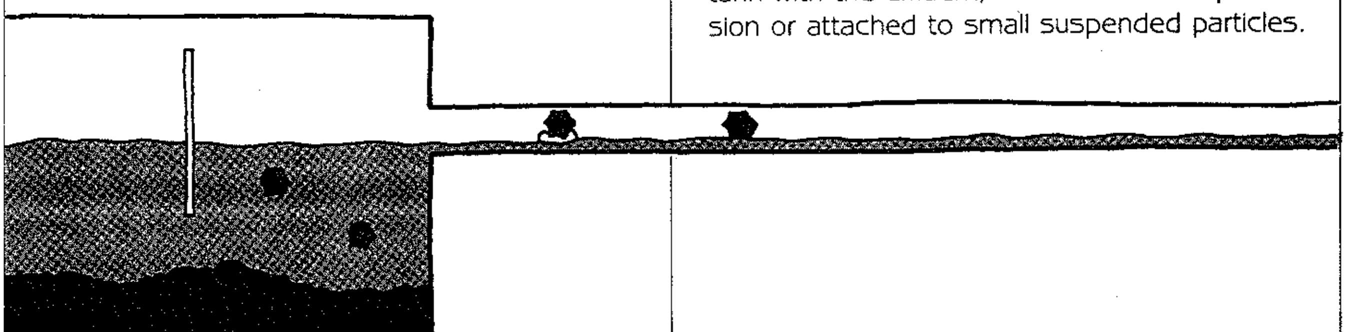
Viruses transmitted indirectly through the environment must be tough, or they will be inactivated (lose their ability to cause infection) before they reach a susceptible person.

On-site wastewater treatment usually starts with a *SEPTIC TANK*.

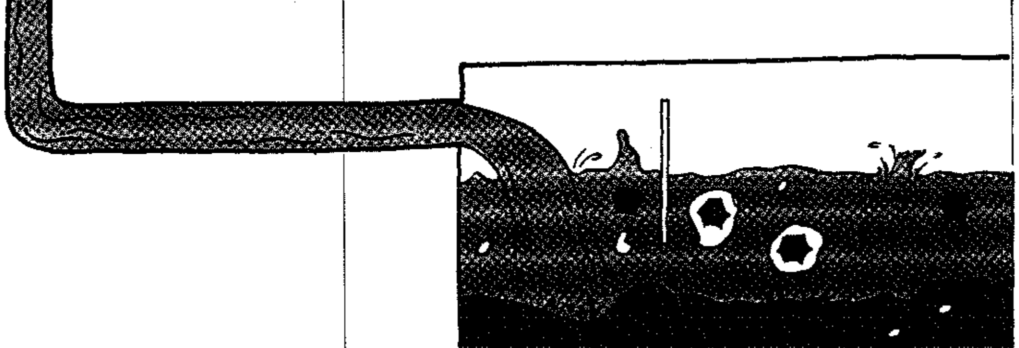
Viruses arrive in the septic tank with feces from a WATER-CARRIAGE TOILET. There they are likely to settle because they are attached to fecal solids; the virus particles are too small to settle by themselves.



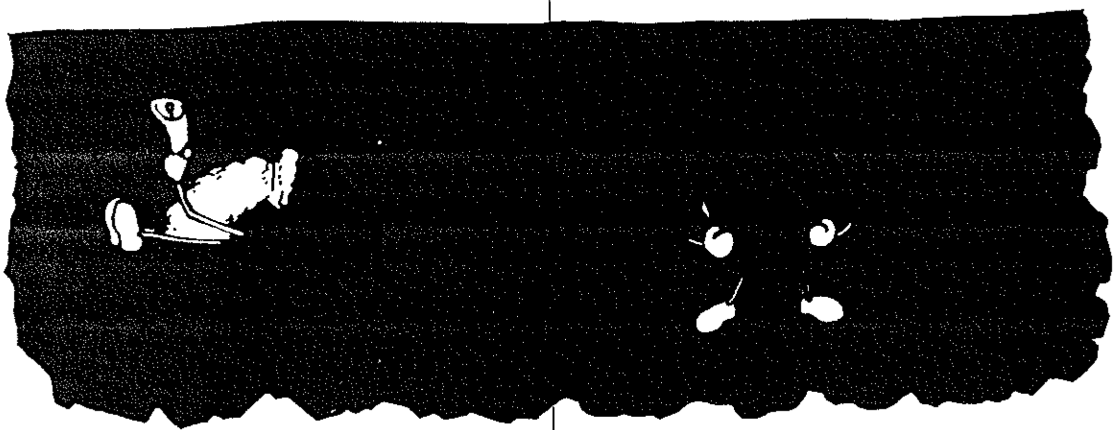
But some of the viruses go out of the septic tank with the effluent, either free in suspension or attached to small suspended particles.



As some organic solids in the sludge break down, viruses may be liberated into the overlying fluid as a result of gas generation or fluid surges; these viruses, too, go out with the effluent.

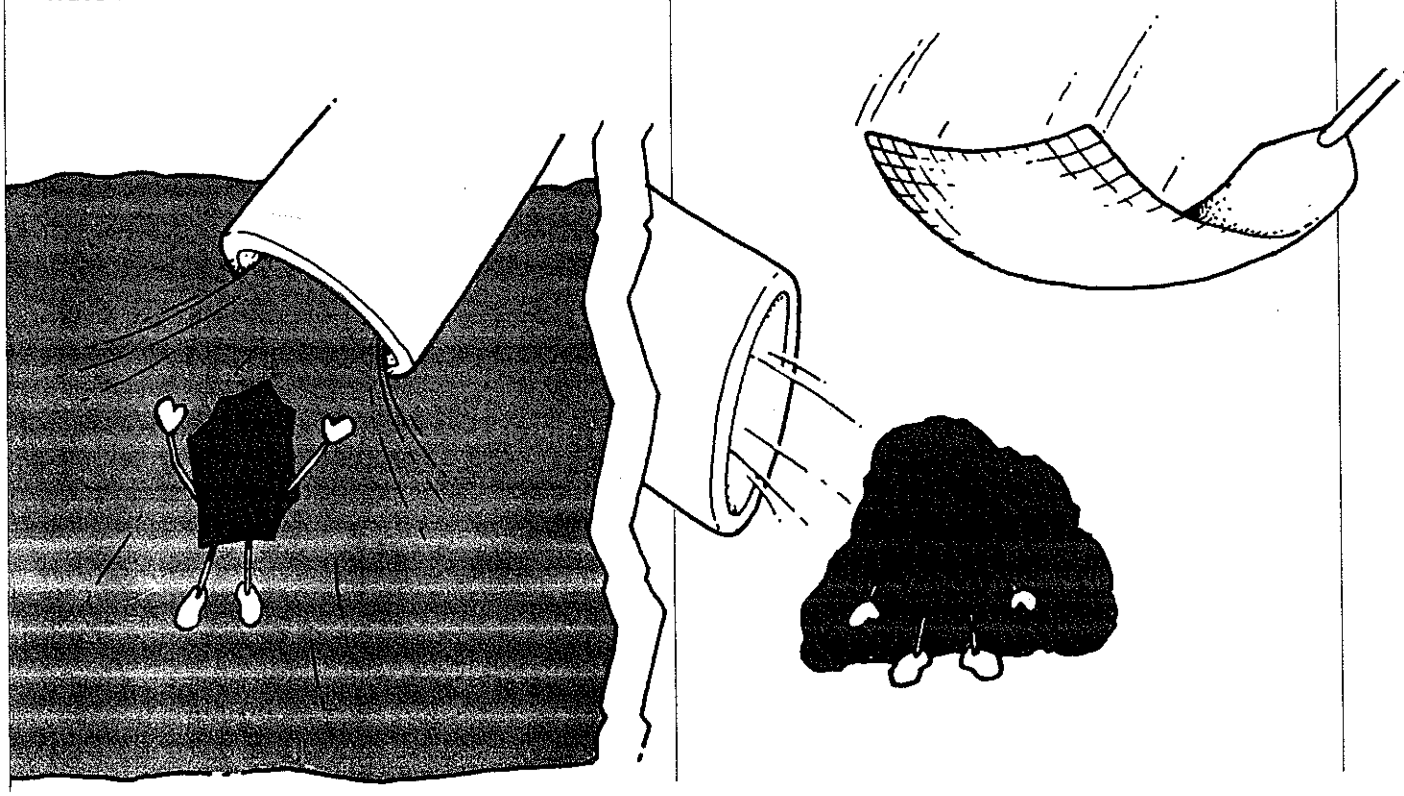


Some viruses remain in the sludge until the tank is pumped. These viruses slowly lose infectivity.



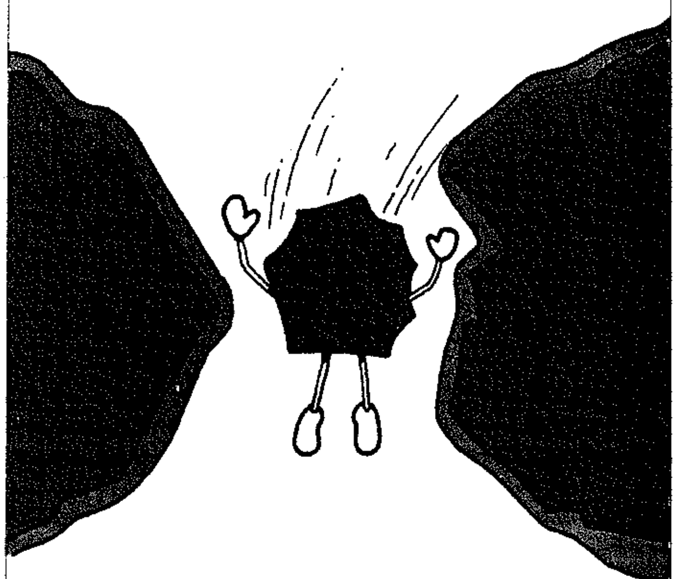
Not all septic tanks contain viruses because most people (and therefore most families) are not infected with and shedding viruses most of the time. But when viruses are present, levels tend to be higher than in city wastewater.

Because viruses accumulate in sludge, SEPTAGE pumped from septic tanks may be rich in viruses and should be disposed of very carefully. Efficient, inexpensive means for disinfecting septage have not yet be devised.



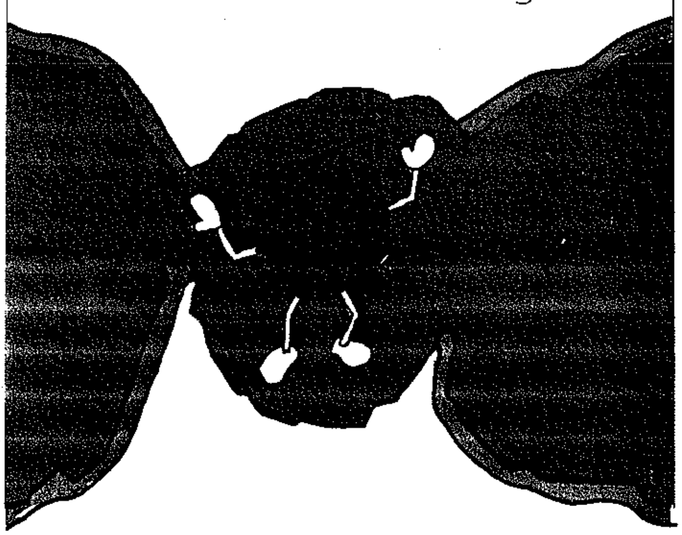
Although some pollutants have been removed, effluent from a septic tank is never very pure. The remainder of treatment is usually done in SOIL.

This is not merely disposal, in the sense that the wastewater goes away. The water in the effluent will eventually be used by other people, so what is being done at this stage is



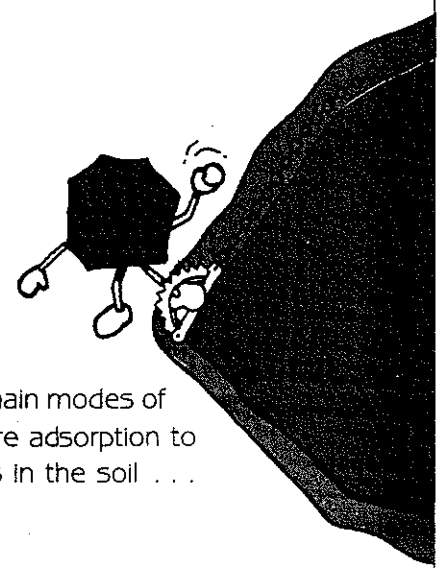
Viruses are small enough to pass freely through the spaces between soil particles,

unless the viruses are attached to larger solids.



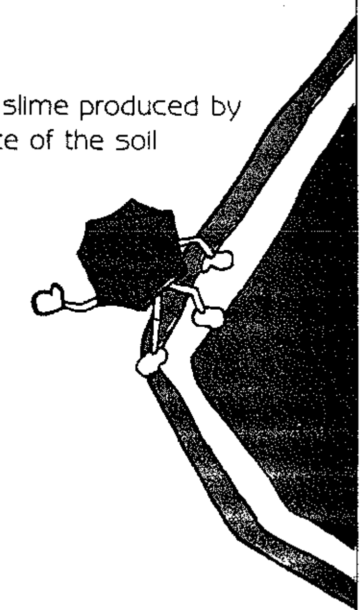
WATER RECLAMATION. From the standpoint of pollutant removal, the soil phase is, by far, the more important step in treatment.

Soil for wastewater treatment needs to be adequately permeable, but have a fine enough texture so that the solid particles expose a great deal of surface to interact with the wastewater.

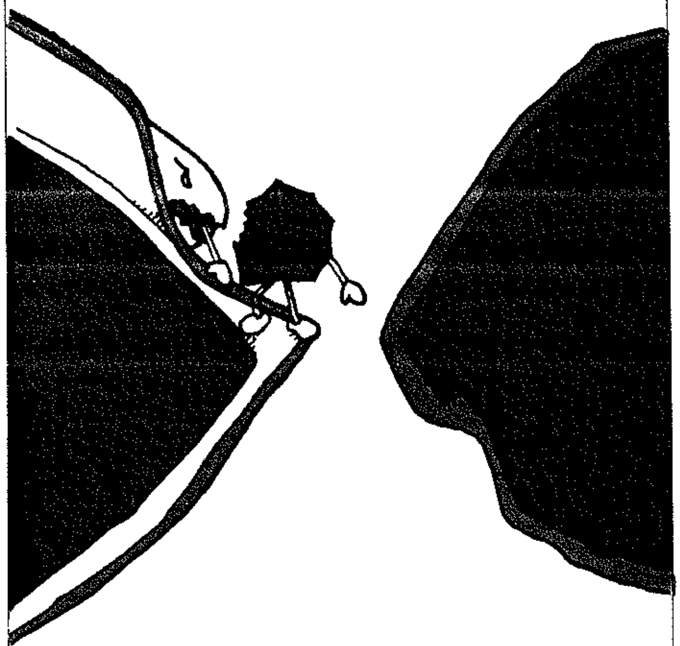


Therefore, the main modes of virus retention are adsorption to mineral particles in the soil . . .

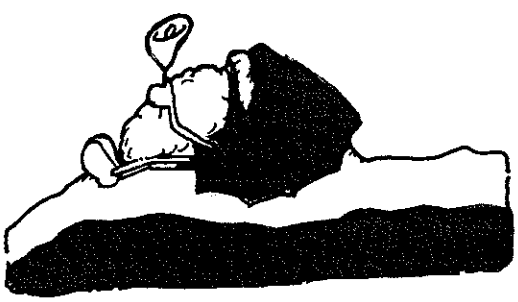
. . . and adhesion to slime produced by bacteria on the surface of the soil particles.

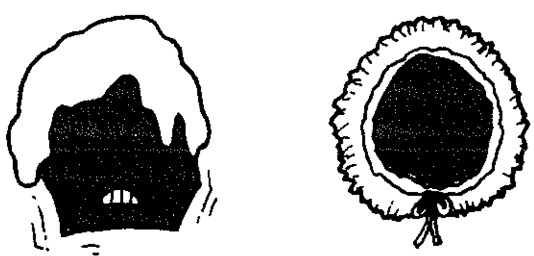


Bacteria living on the soil particles may destroy the infectivity of viruses.



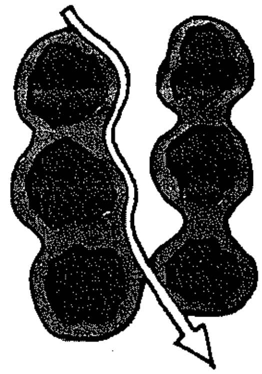
If the viruses are held long enough, they will lose infectivity due to "old age."



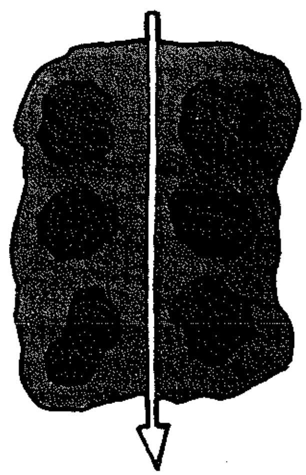


However, at soil temperatures near freezing, viruses are hardly inactivated at all.

UNSATURATION (the presence of air spaces in the voids between soil particles) appears to be very important in wastewater purification and virus retention.

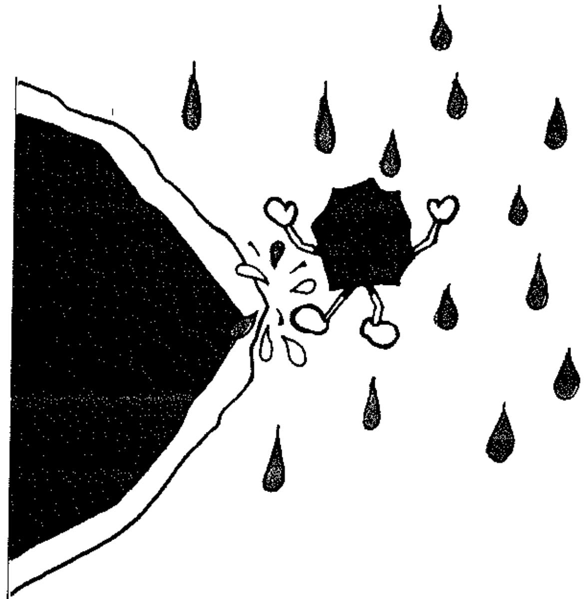


If the soil voids are entirely filled with groundwater, few viruses are retained.

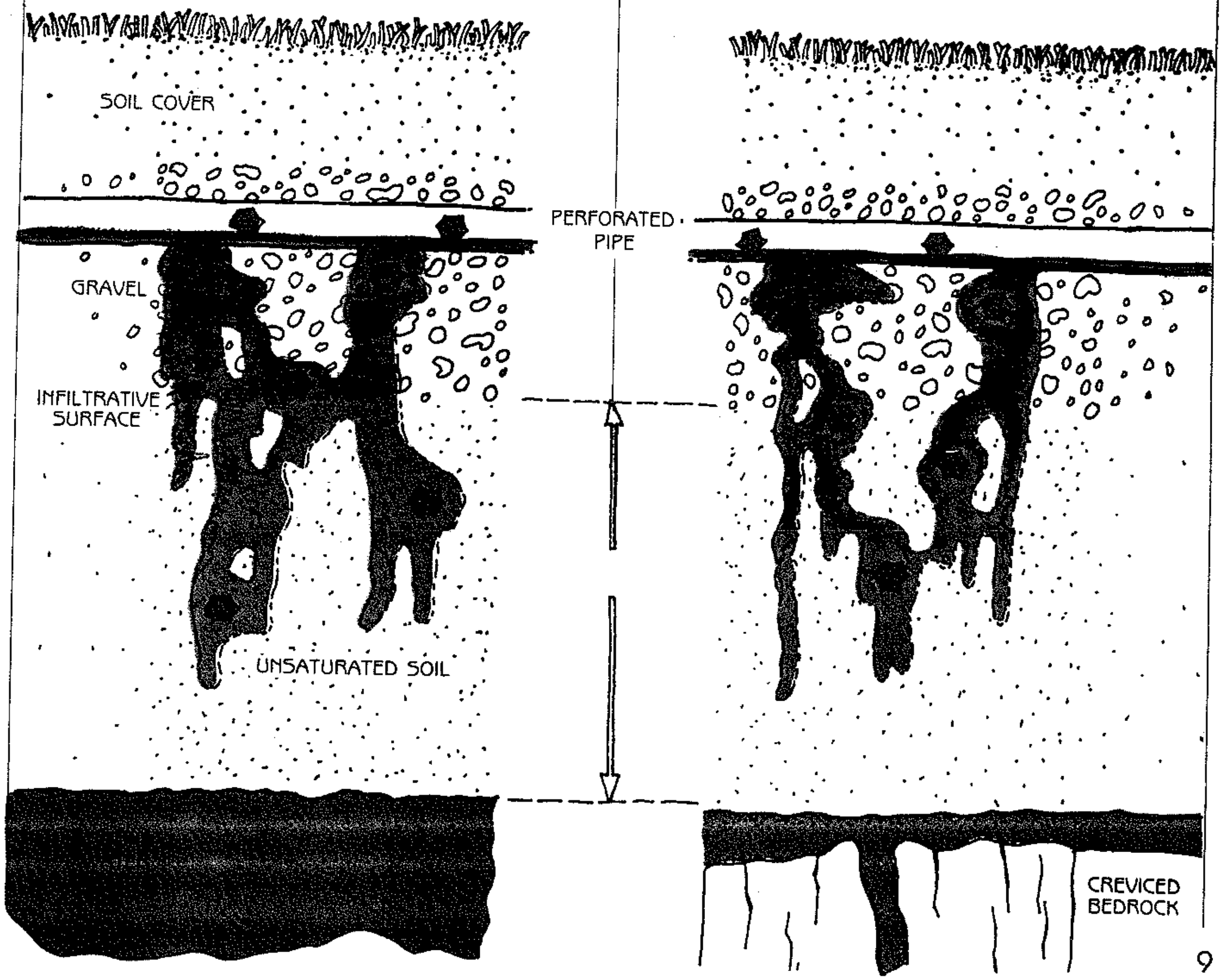


Viruses in the saturated zone travel with the groundwater (though perhaps not quite as fast), subject only to "loss" by dilution, until they reach an exposed land surface, or possibly someone's well.

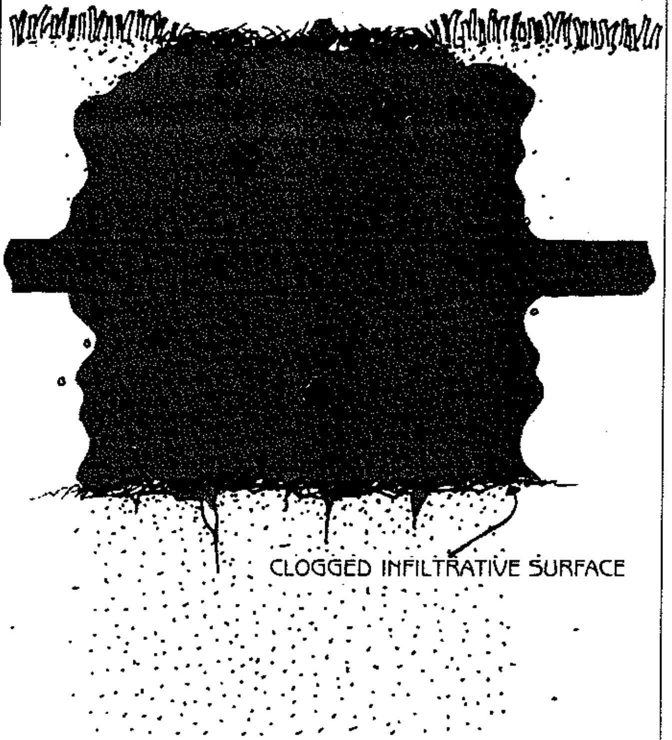
Heavy rains may sometimes displace viruses that have been absorbed or adhered to soil particles. This is likely to depend on the type of soil, the depth beneath the surface at which the virus is retained, and the rate of rainfall compared to the rate at which wastewater is applied to the soil.



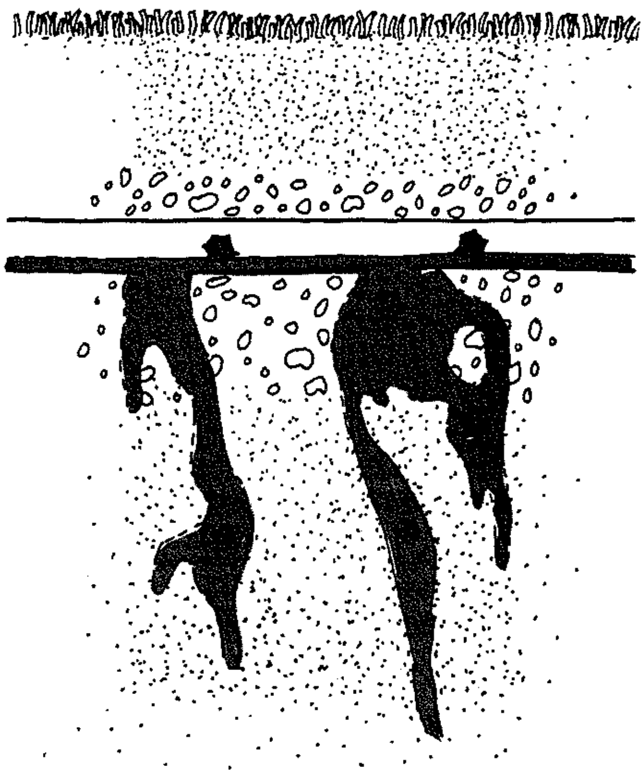
The DEPTH of unsaturated soil needed for safety, measured from the infiltrative surface (where the wastewater actually enters the soil for treatment) to groundwater or to creviced bedrock, is probably at least 3 ft., though this can be reduced to 2 ft. if the wastewater is applied with *very* good control.



FINER TEXTURED SOILS (such as those with a lot of clay) will retain virus well *but only if all the wastewater gets into the soil*. . .

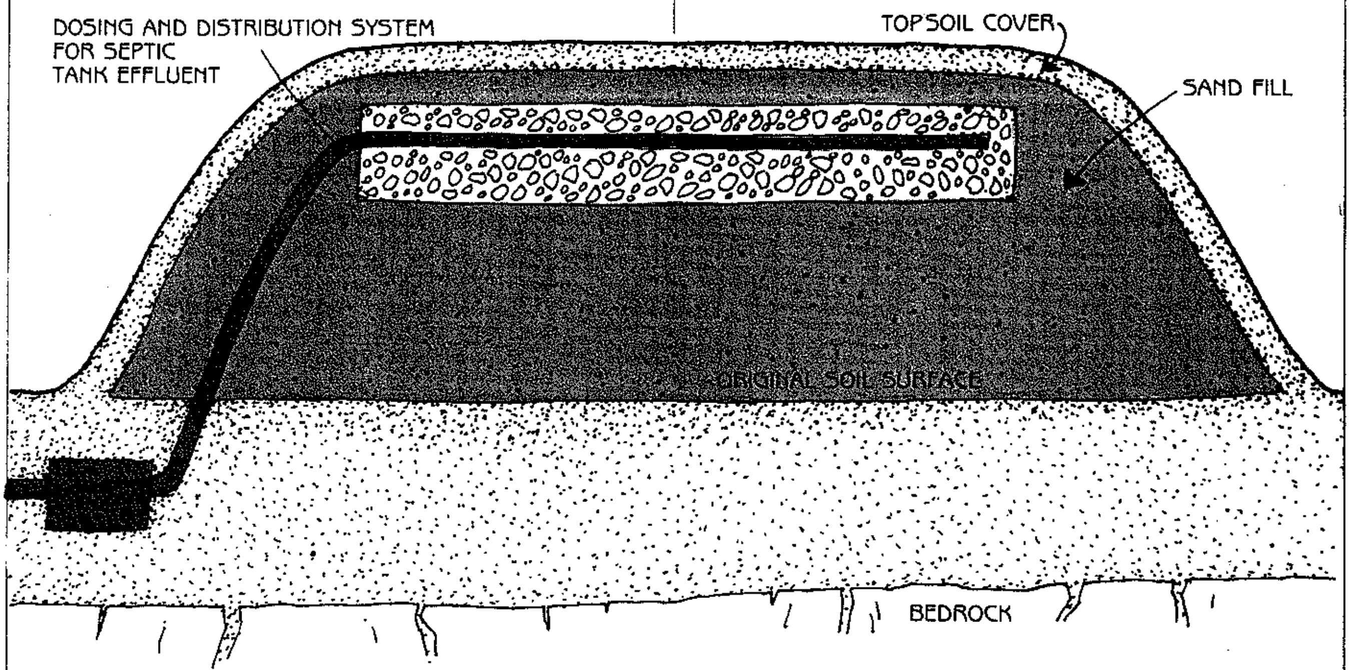


. . . and if the wastewater does not escape purification by passing through major voids (cracks and perhaps worm channels).



PRETREATMENT (such as sand filtration) may be needed in some instances before septic tank effluent enters certain soils. Filtration *and disinfection* are minimum requirements for wastewater discharge *to the surface or to surface waters.*

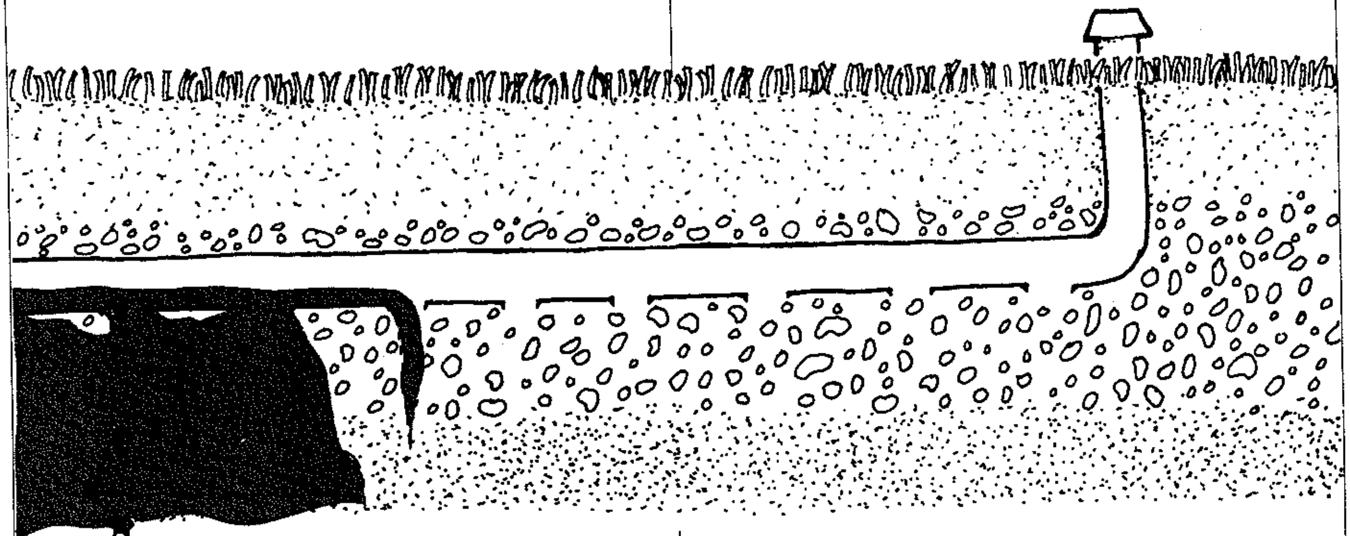
A MOUND of sand, 2 feet deep, built on top of the ground, provided with a properly designed wastewater distribution system (ordinarily based on a dosing tank and pump), and covered with topsoil, can provide adequate wastewater treatment where groundwater is near the soil surface or where only a shallow cover of soil exists above creviced bedrock.



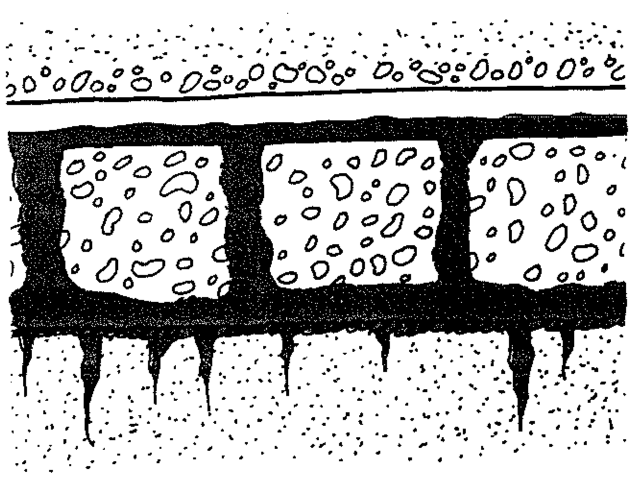
Shallower sand mounds are used to ensure proper wastewater infiltration into slowly permeable soils, but are not primarily responsible for virus retention (the fine soil does that).

Designs and specifications for mounds based on Small Scale Waste Management Project studies are available from the University of Wisconsin Small Scale Waste Management Project, 240 Agriculture Hall, 1450 Linden Drive, Madison, WI 53706.

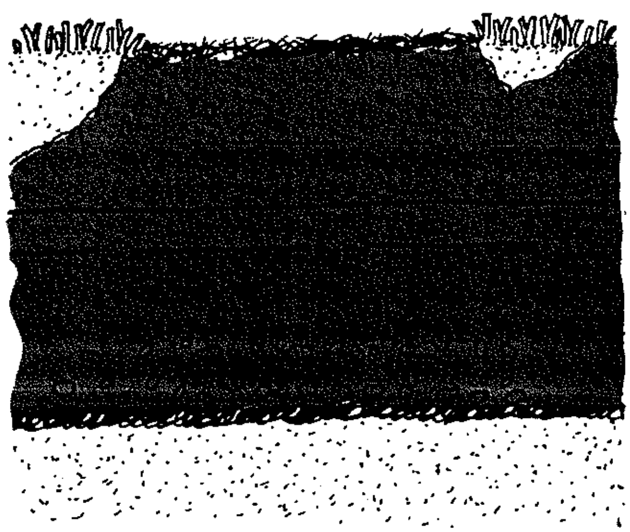
NEW CONVENTIONAL SYSTEMS, using gravity-fed infiltration of septic tank effluents through large-bore pipes, may not produce adequate virus retention when new because the effluent passes into the gravel only under the first few holes in the pipe and produces a saturated condition in the soil in that area.



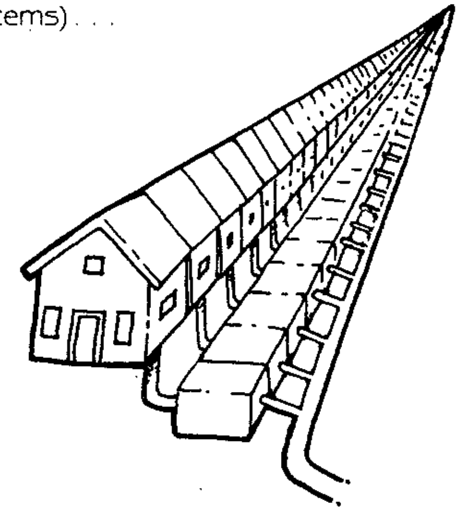
CLOGGING of the infiltrative surface eventually slows wastewater entry and prevents saturation, . . .



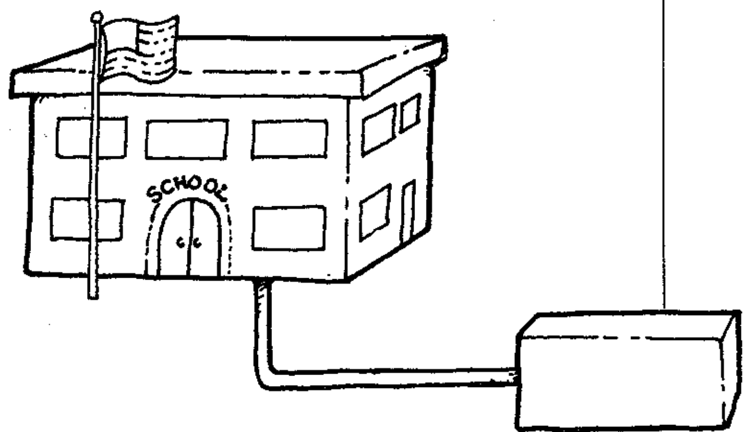
. . . but may in time stop all wastewater entry and treatment.



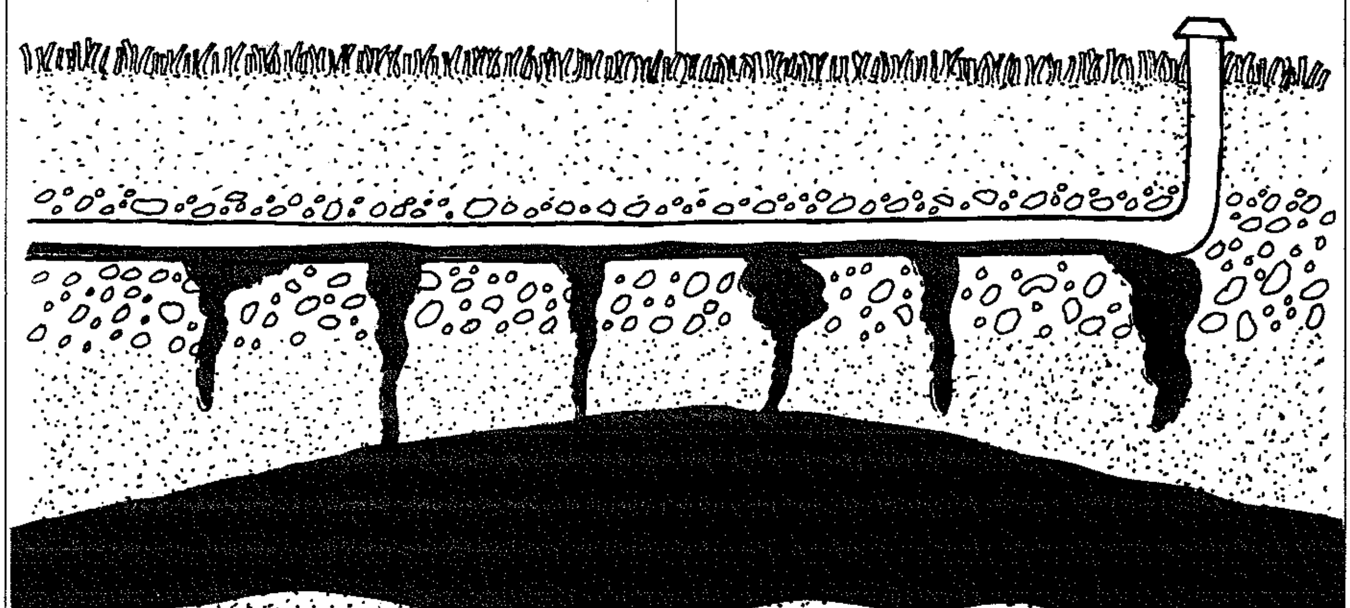
On-site systems that serve LARGE NUMBERS OF HOMES (sometimes called cluster systems) . . .



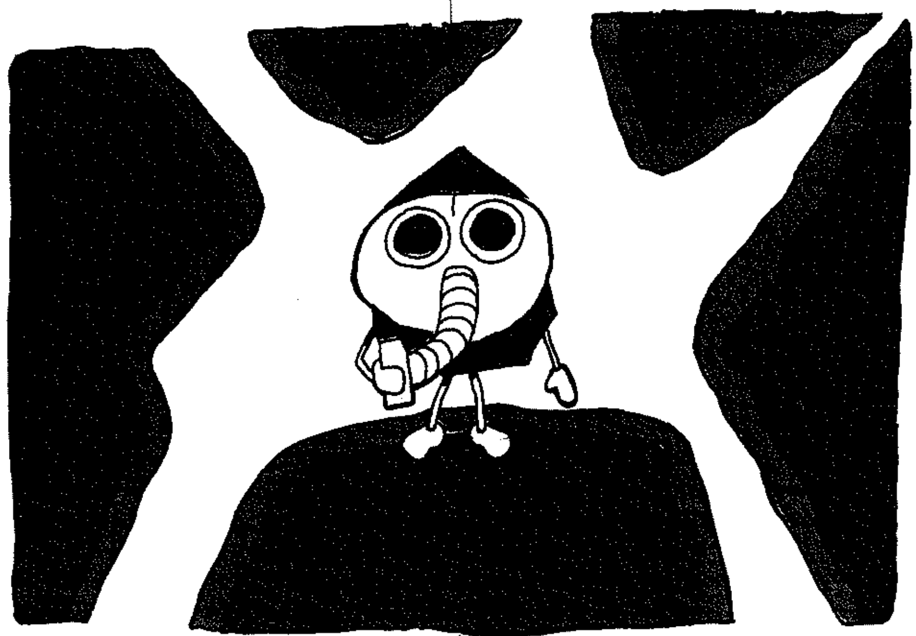
. . . or that treat LARGE VOLUMES OF WASTEWATER in soil may apply the wastewater at or below the soil surface.



If the wastewater is applied very evenly, an unsaturated treatment zone can be maintained in the soil. This depends upon soil and groundwater surveys and systems designed to prevent "mounding" of the groundwater to less than 3 ft. from the infiltrative surface.



Air in the soil voids of these large systems may lack free oxygen; whether this situation affects the fate of viruses has yet to be determined.



Whether an on-site system has to treat large volumes of wastewater or the output of a single family, the potential for virus transmission is always present. Site selection and the design, installation, and maintenance of on-site wastewater treatment systems are all critical to the protection of public health. It is reasonable to expect that, with proper care, on-site wastewater treatment systems can prevent transmission of viruses all of the time.

FOR FURTHER READING

Building a Home in the Country? What You Should Know about Your Septic Tank System by R.J. Otis. Small Scale Waste Management Project, University of Wisconsin-Madison, Circular G1071, April 1981.

Management of Small Waste Flows by the Small Scale Waste Management Project. EPA-600/2-78-173, September 1978. U.S. Environmental Protection Agency, Cincinnati, OH 45268.

Health Effects of Land Treatment: Microbiological by N.E. Kowal. EPA-600/1-82-077, May 1982. U.S. Environmental Protection Agency, Cincinnati, OH 45268.

List of Publications of the Small Scale Waste Management Project (revised annually). Small Scale Waste Management Project, University of Wisconsin-Madison, Room 240 Agriculture Hall, 1450 Linden Drive, Madison, WI 53706.

The Research Division of the College of Agricultural and Life Sciences, University of Wisconsin–Madison, publishes this information in support of its programs and provides equal opportunities in employment, programming and admission. Single copies of this publication are available free to Wisconsin residents from the Agricultural Bulletin Building, 1535 Observatory Drive, Madison, WI 53706. The Agricultural Bulletin Building quotes prices for bulk orders. Order by serial number and title.

1984 *Dean Cliver is a professor in Food Research Institute and the Department of Bacteriology, University of Wisconsin–Madison.*

R2740 VIRUSES AND SEPTIC TANK EFFLUENT **R-01-84-2M-S**