Soil Pollution and Environmental Health

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ALTHOUGH STANDARDS have been established for levels of air and water pollution, relatively little research has been directed toward establishing standards for levels of soil pollution. The resultant lack of information poses a burdensome problem on public officials charged with determining the suitability of soils for the sanitary disposal of septic tank effluents.

Pollution of natural soils and ground and surface waters by effluents from septic tanks is a serious concern. With the burgeoning development of suburban and rural areas, the number of families not serviced by sanitary sewerage distribution systems continues to increase. In these situations, the septic tank and subsurface absorption field are usually employed for disposal of domestic waste. As early as 1959, Olson (*1*) reported that approximately 4 billion gallons of partially treated waste annually seeped into the soils of the United States.

It is often difficult to dispose of human and domestic wastes without creating a nuisance and health menace. The Public Health Service (*2*) has advocated the following requirements for satisfactory disposal of such waste in a manner that:

1. They will not contaminate any drinking water supply.
2. They will not give rise to a public health hazard by being accessible to insects, rodents, or other possible carriers which may come into contact with food or drinking water.
3. They will not give rise to a public health hazard by being accessible to children.
4. They will not violate laws or regulations governing water pollution or sewage disposal.
5. They will not pollute or contaminate the water of any bathing beach, shellfish breeding ground, or stream used for public or domestic water supply purposes, or for recreational purposes.
6. They will not give rise to a nuisance due to odor or unsightly appearance.

Soils and Public Health

In many localities public health officials are involved in the decision of determining which soils are satisfactory for the sanitary disposal of waste. Staff of the Virginia Department of Health made more than 38,000 soil evaluations for septic tank installations in 1970, a peak year. These soil evaluations for a drainfield system follow a systematic approach including consideration of physi-

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ographic province, position of landscape, degree of slope, and soil profile (thickness of horizon, color, and texture). Such evaluations indicate whether use of the particular soil is practicable because of its position in the landscape, seasonal water table, shallow depths, rate of absorption, or a combination of any of these factors. These evaluations are an essential preventive function to reduce health risks by assuring a more proper waste disposal than builders would be likely to provide without guidance.

Establishing and maintaining adequate criteria for satisfactory waste disposal are difficult because of the heterogeneous nature of the soil media. Sprawling subdivisions with individual septic tank systems are rapidly altering natural water runoff and infiltration.

Subdivisions have limited use for septic tank systems, particularly in soils that are marginally suited for such installations. As a public health measure, installation of septic tanks should be discouraged in favor of sanitary sewer systems.

Soils are used for dispersion, filtration, assimilation, and biodegradation of nutrients, anionic surfactants, and biological contaminants before effluent enters ground water supplies. Suitable soils adequately dilute, degrade, and assimilate waste. However, the use of marginally or poorly suited soils for septic systems often results in flagrant soil pollution and health risks.

Many soils may be excessively wet, shallow, or steep or too porous to assimilate septic tank effluent adequately. Poorly suited soils may appear "high and dry" during a few months of the year, but their normal wetness condition presents a stark contrast.

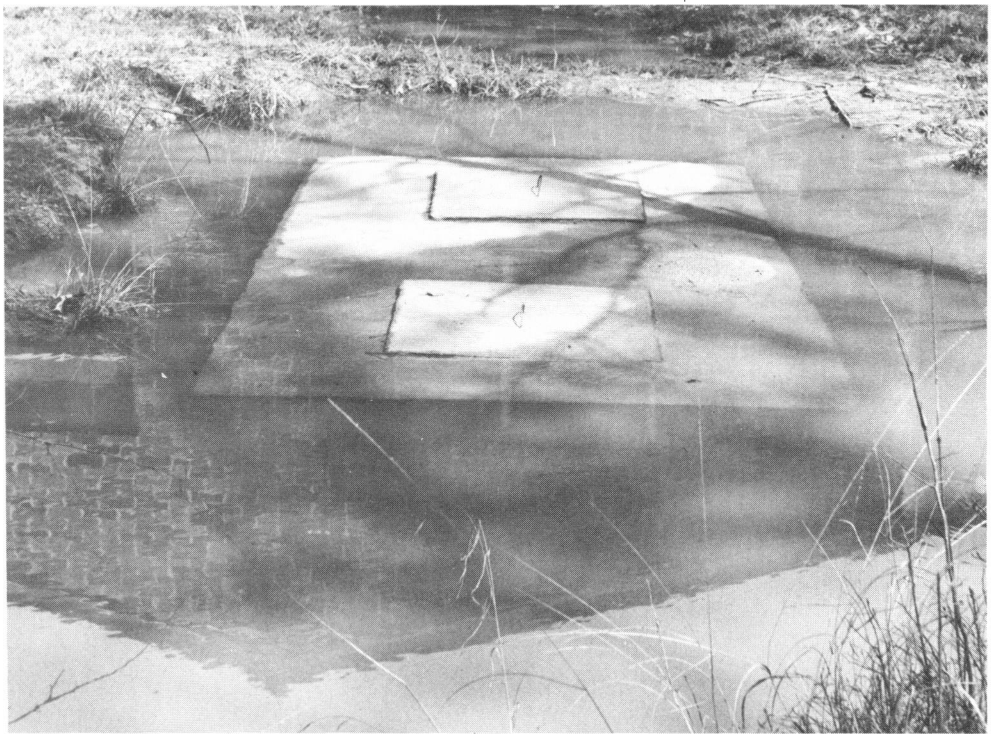
Gradual failure of septic systems may be evident from lush darker colored vegetation nourished by high-nutrient sewage effluents. The darker colored vegetation is surrounded by apparently normal vegetation. Undetected, many of the failing systems may indefinitely continue to seep nutrients, bacteria, viruses, and other chemical and biological contaminants into the adjacent soils and water supplies.

Nature of Domestic Sewage

Household sewage entering septic tanks normally consists of waste from toilets, baths, kitch-

Photograph by W. J. Edmonds, Emporia, Va.

A recent housing development using septic tanks



Photograph by W. J. Edmunds, Emporia, Va.

Ponded raw sewage emitted from the septic tank, contaminating the lawn and homesite in a densely populated area

ens, and laundries. This waste usually is more than 99 percent liquid (*3*).

In 1952 raw domestic sewage was reported to contain from 15 to 35 ppm nitrogen and 2 to 4 ppm phosphorus (*4*). However, since the advent of detergents and water softeners, concentrations of phosphorus may be much higher. Frink (*5*) estimated in 1970 that half the phosphorus in domestic sewage could be attributed to detergents.

Polta (*6*) indicated that septic tank effluent from a family of five represents approximately 5 pounds of phosphorus and 27 pounds of nitrogen applied to the soil each year. Thomas and associates (*7*) observed coliform bacteria counts in septic tank effluents to be of the order 3×10^7 to 3×10^8.

Movement of Effluent in Soils

An example of contamination by movement of septic tank effluent through poorly suited soils was reported by Frink (*8*) in 1971. He stated that the major sources of nutrients in the Candlewood Lake Watershed of Connecticut originated from septic tank systems serving homes. Leakage from septic tank systems was estimated to have contributed about 60,750 pounds of nitrogen and 2,250 pounds of phosphorus per year to this watershed.

Evidence indicates that only small amounts of nitrate are physically or chemically fixed in most soils (*9*). Thus, nitrate in most instances may be considered mobile in the natural soil system. Nitrate can be effectively removed from the natural soil system by microbial immobilization or denitrification. The mobility of nitrate in the soil-water system is of interest because of its contribution to eutrophication.

Phosphorus is also a major consideration in any study dealing with disposal of domestic wastes. In terms of waste disposal, the quantity of phosphorus that soils can "fix" varies tremendously, depending on the physical and chemical properties of the soils. Fixation is the process whereby readily soluble compounds become less soluble by reacting with soil components. The resulting compounds become restricted in their mobility in soils (*10*). Data suggest that movement of phosphorus through soils is dependent on differences of the soils, such as content of organic matter, the amount and type of clay, pH, particle size, and the presence of amorphous hydrated oxides.

Webber and Elrick (*11*) have emphasized the necessity of studying biological pollution of waters because of contamination of water by bacteria and viruses transported through the soil system. Stiles and Crohurst (*12*) detected viable bacteria that have traveled 232 feet in porous soils with the ground water from sewage-flooded trenches some 2½ years after the initial flooding. Bacterial pollution occurred largely at the interface of the ground water surface and the capillary water zone. Kulp (*13*) reported that coliform bacteria have survived up to 4 years in soils. It should be noted that insofar as bacterial pathogens are concerned, the coliform group is considered only as a reliable indicator of adequate removal. Undoubtedly, mobility and survival of various disease-producing organisms vary with types of soil.

New Research in Soil Pollution

Little information is available about the movement of enteric bacteria, viruses, surfactants, and nutrients through natural soils. Because of this need for factual data under existing conditions, a cooperative research program was initiated in July 1971 by the Virginia State Department of

Darker colored grass outlines the septic tank drainline of a system beginning to fail

Photograph by W. J. Edmunds, Emporia, Va.

Excavated drainlines for a new septic tank in wet soil which had been approved during a dry period

Health and the Research Division, Agronomy Department of Virginia Polytechnic Institute and State University. The objectives of this project are to establish parameters considering the effect of the physical, chemical, and morphological properties of soils on the dilution, assimilation, and filtration of organisms, nutrients, and surfactants in septic tank effluent as a function of time.

Bacteria and virus contamination is of particular interest because of a complete lack of information on the (*a*) viability of organisms in natural soil systems, (*b*) their interaction with soil, and (*c*) the nature and extent of movement. The relevance of this research to water resources problems was recently expressed vividly in national print when Michigan State University scientists Mack and Coohon (*14*), for the first time, isolated a type 2 poliomyelitis virus—of the kind used in oral poliomyelitis vaccines—in a drinking water supply taken from a 100-foot well. The poliomyelitis virus was suspected of having seeped through the soil from a sewage system to contaminate the water supply. This finding is an example of the potential health hazard in soil and water supplies, and this kind of hazard could become more pronounced with increasing population density.

Public health officials are also frequently perplexed by the extent of health and pollution hazards produced by the lateral drainage of septic tank effluents into streams and other natural bodies of water.

After more than a decade of cooperative soil research related to environmental health, the Virginia State Department of Health and the Agronomy Department of the Virginia Polytechnic Institute and State University have initiated a 3-year study of the movement of septic tank effluent in natural soil systems. One objective is to discover the health and pollution hazards inherent in using soils to dispose of septic effluents.

Using data and methodology developed during preliminary research, experimental sites have been established on selected soils to monitor horizontal and vertical movement of effluent from typical domestic septic tank systems. The specific action of restricting soil layers and fluctuating water tables on effluent movement will be examined in detail.

Particular attention will be directed to the relationships between two groups of coliform and other bacteria in diluted effluent to determine their mobility and longevity in natural soils. Movement of associated viruses will also be studied.

When it is applied, the results of this project should provide measurable and scientific bases for decisions on the location of septic tanks.

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