On-Site Sewage Disposal

The importance of the wet season water table

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Abstract

Effluent entering a soil absorption system may contain varying combinations and amounts of potential contaminants. A vertical separation distance of 24 inches between the bottom of a soil absorption system and the seasonally high water table has been suggested as a minimum soil depth for proper treatment of effluent and protection of groundwater. Depth to the wet season water table can be monitored with observation wells or can be estimated from soil morphological characteristics. Caution is advised when evaluating artificial drainage as a method to improve performance of on-site sewage disposal systems.

Proper functioning of an on-site sewage disposal system (OSDS) is achieved only if a sufficient volume of soil is available to absorb the effluent and to treat it (1). A vertical separation distance of 24 inches between the bottom of the absorption system and the seasonally high water table is suggested by the U.S. Department of Housing and Urban Development (2).

Effluent entering a drainfield may contain varying combinations and amounts of potential contaminants. These contaminants nearly always include nitrogen, phosphorus, suspended solids, sulfates, chlorides and sodium. Constituents also may include detergents, toxic organic compounds, heavy metals, pathogenic bacteria and viruses, depending on use of water and the health of a system's users at any given time (3).

The behavior of various effluent constituents can be highly variable, depending on the nature of the particular constituent, on the nature of the soil and on the degree of saturation of the soil. The degree of saturation is strongly influenced by the depth to the wet season water table.

The water table, or boundary between unsaturated soil above and saturated soil beneath, may fluctuate widely during rainy seasons and as rates of evapotranspiration change with seasons. One of the keys to proper functioning of an OSDS is to ensure that the vertical distance between the bottom of the drainfield is large enough so that unsaturated conditions will be maintained even during wet seasons.

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Maintenance of an unsaturated zone beneath a drainfield helps ensure good aeration and slow travel of effluent. Aeration is important in achieving decomposition of organic particles and compounds, biodegradation of detergents and die-off of bacteria and viruses. Slow travel permits maximum contact between soil particles, extended opportunity for natural die-off of bacteria and viruses and biodegradation of degradable materials.

Water travels more slowly through an unsaturated soil whose pores are not entirely filled than it would through the same soil were it saturated. The slower the velocity of flow, the longer the effluent will remain in the unsaturated zone and the greater the opportunity for its cleanup. Effluent that does not travel through an unsaturated zone will not be aerated and is likely to reach groundwater with its initial content of potential contaminants essentially unchanged.

A scientific basis exists then for requiring an unsaturated zone beneath a drainfield. EPA's *Design Manual — Onsite Wastewater Treatment and Disposal Systems* (4) and Miller and Wolf (5) recommend a water-unsaturated soil depth beneath the absorption system of from 24 to 48 inches. Groundwater monitoring studies by Carlile et al. (6) and Cogger and Carlile (7) found that the concentration of effluent contaminants in groundwater decreased as the vertical separation distance between the bottom of the absorption system and the seasonally high water table increased.

Numerous field studies (8,9,10,11,12, 13,14) and laboratory studies indicate that a 24-inch depth of water-unsaturated soil below the absorption system may not always be adequate to prevent passage of bacteria and viruses to groundwater. Other studies indicate that the depth of water-unsaturated soil necessary to prevent groundwater contamination should perhaps be determined by the permeability of the soil. Soils with relatively rapid permeabilities, such as sand and loamy sand, may require a greater depth of water-unsaturated soil below the absorption system that soils with relatively slow permeabilities.

To design as OSDS such that groundwater will not occur within 24 or 36 or 48 inches below the bottom of the absorption system requires a knowledge of the seasonal high groundwater elevation at the site. Seasonal high water tables can be determined with groundwater monitoring wells maintained and read over a period of several years, if time and resources permit. It is unlikely, however, that data would be available for every site of interest.

Ordinarily, long-term well data is not readily available. Instead, the wet season water table must be estimated by examining the soil's color patterns, other features of the soil profile, landscape position and vegetation (1,15,16,17,18,19,20). Bouma (1) noted that groundwater observations prior to OSDS installation are often made when groundwater is below the maximum groundwater elevation. Installation of an OSDS without accurate knowledge of the seasonal high water table can result in a decreased separation distance due to rising water tables and decreased effluent treatment.

Effluent discharge from an OSDS drainfield recharges groundwater and may result in mounding or raising of the groundwater beneath the system. Mounding of the underlying groundwater can reduce the unsaturated soil depth through which the effluent moves, and thus decrease effluent treatment (21,22,23).

The possibility of such mounding, coupled with the likelihood of a capillary fringe occurring in the zone just above the water table, heightens the importance of determining the wet season water table accurately and ensuring a separation of at least 24 inches.

Soils containing impermeable or slowing permeable soil horizons commonly develop perched water tables during periods of high rainfall. Perched water tables can result in saturated flow of effluent, reduced treatment of effluent, lateral flow and/or transport of the effluent to the soil surface (24,25).

Alternative systems such as mounds and/or fills have been recommended and/or used to increase the separation distance between the bottom of the absorption system and the seasonal high water table, bedrock or unsatisfactory soil material.

Artificial drainage can increase the water-unsaturated soil depth below an absorption system, and has been shown in some instances to improve the hydraulic functioning of OSDSs (10,24,25,26,27). The water table can be drawn down in wet areas by various methods, including canalization, pumping for irrigation and/or municipal use, agricultural drainage works such as surface and subsurface drains, and road ditches. The most obvious direct effects of drainage have been the lowering of water tables, alterations in soil moisture regimes and changes in ecosystems and land use.

Caution is advised, however, in estimating the effects of drainage on individual tracts of land. The precise effects in any one locale can be estimated only by careful analysis of conditions at the site. A single ditch across an equidimensional 100-acre tract of land, for example, is not likely to influence the water table beyond an area 30 or 40 feet wide on either side of the ditch, unless the ditch is deep and wide and has a positive outfall or head gradient leading to rapid removal of water from the site, and unless the soils are sufficiently permeable to allow removal.

Adequacy of drainage works is a function of the permeability of soils and underlying substrata; the presence or absence of restrictive layers such as hardpans; the depths of canals, tile drains or wells; the distance between drainage devices; and the establishment and maintenance of adequate flow rates from the site.

Uebler et al. (27) examined feasibility of artificial drainage in improving OSDS performance in North Carolina. The soils were in the Leon series, a flatwoods soil whose organic-stained subsoil horizon ("spodic horizon" or "hardpan") can have varying degrees of cementation and restriction to water movement, depending on location. Where the subsoil horizon was massive, strongly cemented, hard, brittle and greater than 4 inches thick, the water table could not be lowered sufficiently to achieve a 12-inch separation (the North Carolina requirement) between the trench bottoms and the wet season water table, where a subsurface tile line was located 50 inches deep and 25 to 35 feet from the OSDS drainfield trenches.

On the other hand, where the organic-stained layer was weakly cemented and/or less than 4 inches thick, the water table could be lowered sufficiently to meet North Carolina code. The nature of the perching layer, in this case an organic-stained subsoil horizon, had a strong influence on the feasibility of using artificial drainage to lower the water table.

Water travels more slowly through an unsaturated soil whose pores are not entirely filled than it would through the same soil were it saturated. The slower the velocity of flow, the longer the effluent will remain in the unsaturated zone the greater the opportunity for its cleanup.

Drainage facilities that do succeed in drawing down the water table may not have entirely beneficial effects. In many instances, depending on the soil, drainage devices such as tile lines or ditches would have to be closely spaced in order to achieve the necessary drawdown for a 24-inch separation beneath an OSDS drainfield. In such cases, the drainage works themselves are likely to have positive outfall downstreams to open water such as a canal, creek or lake, and therefore, should themselves be considered open water.

Thus, while the water table requirement may be met as a result of artificial drainage, required horizontal setbacks between the OSDS drainfield and open water may now be violated. The distances between drainage tiles and the OSDS drainfields in the North Carolina study (27) were between 25 and 35 feet, well under the 75 to 150 required between drainfields and surface water under many state public health codes.

Finally, it should be recognized that human activities may cause the water table to rise, rather than fall; for example, where paving and buildings concentrate infiltrating rainwater in smaller areas of land than would be available under natural conditions (28). Stormwater retention/detention facilities, designed to keep runoff from rapidly exiting urban watersheds, might also serve to keep the water table from falling as rapidly or as far as it otherwise would, as could blockage of drainage works by sedimentation, accumulated debris or check dams.

Summary

Proper operation of an OSDS occurs only when a sufficient volume of unsaturated soil is available to absorb and treat the effluent. The effluent must pass through an unsaturated zone of soil to ensure good aeration and slow travel, which are needed to achieve decomposition of organic materials, biodegradation of detergents, adsorption of effluent constituents to soil particles, die-off of bacteria and viruses, and other processes contributing to the filtration and treatment of effluent before it reaches groundwater or surface water.

The scientific literature suggests that a separation of at least 24 inches is necessary to achieve adequate treatment. Depth to the wet season water table must be estimated for each OSDS site, so that the elevation of the bottom of the drainfield can be set to achieve the 24-inch separation. Soil, landscape and vegetative indicators, and perching phenomena, must be studied carefully to make this estimate.

Caution should be used in evaluating the impact of artificial drainage on water tables. Often the influence of canals, ditches and/or subsurface tile lines is minimal beyond a short distance horizontally from the drainage device. Conversely, paving and buildings may concentrate runoff water and artificially raise water tables in some locales. Storm water detention/retention devices and accidental blockage of drainage works also may raise water tables.

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