Reducing NPS Pollution From On-site Sewage Disposal
Systems Through Improved Soil Assessment

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Research Problems

On-site sewage disposal systems (OSDS) have been targeted as the leading source of pollution introduction into surface water and groundwater in many regions. It has been estimated that close to 50% of the people of Alabama use OSDS as their method of domestic waste disposal for single-family dwellings. When properly installed in suitable soil, these systems provide a safe and efficient disposal method for domestic waste. Unfortunately, it is apparent in certain regions of the state that a large portion of these systems is failing, and failure numbers seem to be increasing. OSDS failure manifests itself in several ways, including: 1) backing up of effluent to the soil surface (termed surfacing), and 2) leaching of untreated effluent to groundwater. With either situation, deterioration of groundwater and/or surface water quality occurs due to the off-site movement of nutrients, household chemicals, and in some cases, pathogens. In this researcher’s opinion, deterioration of water quality due to OSDS failure is the largest threat to water resources in Alabama. Failures of OSDS mainly occur because the systems are installed in soils that are unsuitable due to poor drainage characteristics and/or the presence of a seasonal high water table (SHWT), which forbids additional hydraulic loading. Health Department personnel and soil scientists typically use features in soil (termed redoximorphic features) to predict the depth to a SHWT and make proper interpretation of soil suitability to hold a functioning OSDS. However, in certain sandy soils (classified in Arenic and Grossarenic subgroups), assessment of redoximorphic features is problematic due to the nature of the sandy materials. These types of soils are termed problem soils. In these soils, it is difficult to predict the height of the SHWT, which sometimes results in erroneous assessment for OSDS suitability. Little research exists that correlates soil redoximorphic features with water table dynamics for these soils.

These concerns have prompted interest from soil scientists at Auburn University and the Alabama Department of Public Health to develop guidelines to better assess the drainage class of certain sandy soils in the Coastal Plain of Alabama. These soils are common, approximately 25% of Baldwin County in Lower Alabama is composed of these types of soils, and OSDS failures are occurring in this region. These soils possess thick sandy eluvial (0.5 to 1.5 m thick) horizons overlying argillic (clay-rich) horizons of reduced permeability. Past studies have shown that lateral gradients of flow associated with subsurface horizons occur in some of these soils, but uncertainties exist about the degree of perched water above the clay-rich horizons and the status of the SHWT. Many of these soils in lower topographical positions also possess true groundwater (related to regional water tables) for significant periods of the year. Because of the problematic morphology and because these soils inherently have limited abilities to sorb and renovate pollutants (e.g. from on-site sewage effluent) in the sandy eluvial horizons, accelerated deterioration of water quality often occurs due to the erroneous interpretations of soil drainage class. This study proposed to assess the drainage class and water table dynamics of these soils.

Research Objectives

The objectives of this study are to: 1) correlate the depth and duration of seasonal water tables in extremely sandy soils of the Coastal Plain of Alabama with certain redoximorphic features, and 2) establish relations that
can be used by soil scientists and health department personnel for estimating depths to SHWT for making better assessments of OSDS suitability.

Materials and Methods

We evaluated the relationship between SHWT and redoximorphic features in Arenic and Grossarenic soil subgroups. Arenic subgroups possess a sandy eluvial layer that extends from the mineral surface down to 50-100 cm, and Grossarenic subgroups have a sandy eluvial layer that extends >100 cm, both of which overly an argillic horizon (Soil Survey Staff, 1997). Three transects were established in Barbour County, Alabama. These sites were chosen to be representative sandy Coastal Plain catenas. The three sites include the Midway Plantation Site (MP) and the Grant sites 1 and 2 (G1 & G2).
Soils at all sites possess sandy eluvial horizons overlying argillic horizons of various depths. MP soils consisted of very deep sands (Aquic Hapludult, Grossarenic Paleudult, and Typic Quartzipsamment). Soils at the Grant sites consist of Arenic Plinthaquic, Plinthaquic, and Arenic Paleudults.

A total of nine nests are being monitored. A nest consists of two piezometers, one well, and ten redox probes placed at depths relative to soil morphology. Three nests at MP (MP1, MP2, & MP3), three at G1 (G11, G12, & G13), and three at G2 (G21, G22, & G23). An electronic tipping bucket rain gauge, a Campbell Scientific CR10X data logger, and soil and air thermocouples are centrally located at each site. The CR10X data loggers are equipped with Campbell Scientific AM416 multiplexers to increase the number of channels available for monitoring.

Piezometers were used to evaluate the potentiometric surface of water tables in soils at specific depths. Piezometers were constructed of 12-inch PVC pipe and perforated using a 3/8-inch drill bit. Piezometers were perforated 15 cm from the bottom in 2.5 cm increments, and covered with a thin permeable cloth to prevent sloughing and deposition of soil within the pipe. For this evaluation, one piezometer was placed just above the argillic horizon in the sandy eluvial horizon, and the other was located within the argillic horizon.

Wells were constructed of 1½-inch PVC pipe and perforated using a 3/8-inch drill bit. The well pipes are continuously perforated from 20 cm below the surface to a depth of approximately 175 cm in 15 cm increments, and thus give a composite view of the free water surface. Differences in water levels between wells and piezometers can help differentiate zones of perching in the soil.

Water columns within each piezometer and well are monitored using Druck model CS-420 pressure transducers. The two lower nests on each landscape are electronically monitored (MP2, MP3, G12, G13, G22, & G23) while the upper nest (MP1, G11, & G21) is manually monitored. A CR10X data logger records data on thirty-minute intervals. The data consists of the height of the water column in four piezometers and two wells, air and soil temperature, and rainfall. Individual data loggers and other peripheral devices are located at all three transects.

Redox probes are manually monitored as per techniques described by Patrick et al. (1996). The probes were constructed of 10 gauge copper wire with platinum tips, attached using lead-free solder. All copper and solder is covered by a rubber or epoxy coating. The probes were calibrated using a pH buffered, (pH 4 and pH7) quinhydrone solution of known pe. A saturated calomel electrode was used as a reference electrode. Redox probes were placed at depths corresponding to piezometer placement.
Standard Soil Survey techniques were used to describe and sample soils, with Standard Soil Survey techniques redoximorphic features. Soil physical and chemical properties including particle size distribution, exchange capacity (pH 7), and organic carbon content were measured by horizon. Selective extraction thionite, ammonium oxalate, and sodium pyrophosphate techniques) was used. Thionite, ammonium oxalate, and sodium pyrophosphate were used. Mineralogical analyses were conducted using X-ray diffraction (XRD). Saturated hydraulic conductivity ($K_{sat}$) of selected horizons was evaluated using a Compact Constant Head Permeameter (Amoozegar, 1989).

Results

Soils on the lower landscape position (MP3) tended to be saturated more often than soils upslope. MP1 exhibited SHWT for short periods at depths that exhibit redox features. Perching of water tables above argillic horizons does not appear to be occurring at this site.

Initially, the SHWT was observed at MP2 at a depth of 170 cm in June of 2000. On July 6, 2000, no SHWT was present in any of the MP nests. The SHWT was absent from nests until November 2000. At this time the SHWT was observed in MP2 and MP3 nests at varying depths and was still present as of May 7, 2001.

Redox potentials at each MP nest were observed to be within the range required to reduce Fe species beginning in January 2001. Also, redox potentials decreased as duration of saturation increased.

The SHWT at MP was observed for extended periods of time in horizons not exhibiting redox features. For example, the E3 horizon at the MP2 nest has olive yellow (2.5Y 6/6) and pale yellow (2.5Y 7/3) sands, and was saturated for approximately 130 days. Interestingly, some white (10YR 8/1) stripped sands were found in the E2 horizon directly above. The SHWT was observed above the E2 horizon in horizons without redox features for two 15-20 day periods in March and April 2001. The MP3 nest possessed a SHWT at depths above redox features for 45 days in March and April 2001. Other periods of saturation at the MP site have occurred at depths where redox features were present.

Lower landscape positions have been saturated more often than soils upslope at G1. G11 has exhibited SHWT for two very short periods (5-7 days) since monitoring began. The horizons in which saturation occurred mostly possess redox features. Perching of water tables above argillic horizons does not appear to be occurring at this site.

The G1 site was installed in late March 2000. The SHWT was observed at G1 during the month of April through early May 2000. G12 and G13 exhibited water tables at depths of approximately 174 cm and 163 cm, respectively, during this time. During the period from May 2000 until early March 2001 water tables were not observed at G1. At this time the SHWT was observed in G12 and G13 nests at varying depths and was still present as of May 7, 2001.

Redox potentials have been recorded at G1 since early September 2000. Redox potentials in saturated soils at each G1 nest have been observed to be within the range required to reduce Fe species. Also, redox potentials have decreased as duration of saturation increased.

At G1 the SHWT has been observed in horizons not exhibiting redox features for extended periods of time. G12 and G13 nest had a SHWT present for a 35-37 day period in horizons where redox features were not present. In both cases, the horizons were eluvial horizons (E1 and E2) with fine sand features. Some light brownish gray (10YR 6/2) and pale brown (10YR 6/3) stripped sands were identified in the Ap and E1 horizons, respectively, at G12.
The SHWT at the G2 site was first observed in January 2001. At this time the SHWT was observed in the G22 and G23 nests and was still present as of May 7, 2001. At this site, lower landscape nests are saturated more often than the nests located higher on the landscape. The G21 nest had not shown any signs of a SHWT until mid March 2001 following a heavy rainfall event. Perching of water is not evident at this site.

Redox potentials have been recorded at G2 since early September 2000. Redox potentials at each G2 nest have been observed to be within the range required to reduce Fe species when soils are saturated. Also, redox potentials have decreased as duration of saturation increased.

At G2 the SHWT has been observed in horizons not exhibiting redox features for extended periods of time. G12 and G13 nest revealed saturation for several short 5-7 day periods in horizons where redox features were not present.

Conclusions

It is clear that dry conditions over the period of this study complicated our findings.

For these sandy soil catenas, the SHWT tended to be shallower at lower landscape positions. In general, the shallowest depth to saturation (3 cm) occurred in March 2001, corresponding to a period of significant rainfall. Although distinct argillic horizons are present in these soils, our data suggests limited perching of water.

In the lower landscape positions, the SHWT tended to occur above the depth of redoximorphic features. Saturation of soils above redoximorphic features was not observed in the soils situated in higher landscape positions. Thus, it appears that a combination of landscape position and redoximorphic feature evaluation is necessary to fully interpret SHWT depths and duration.

It appears that the SHWT is at its shallowest depths during the early spring. Several rainfall events during the winter and early spring of 2001 have resulted in significant periods of saturation at many of our nests. Our findings have confirmed that SHWTs do occur for significant periods in areas not exhibiting redoximorphic features in some Arenic and Grossarenic subgroups of soils. Extended monitoring throughout the rest of 2001 and through the spring of 2002 should allow a better prediction of the behavior of SHWTs in these soils.