Rural Wastewater

Swelling Clays and Septic Systems

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Shrinking and swelling soils can damage homes, roads, utilities, and septic systems. Each year, Americans spend more than $2 billion to repair damage from expansive soils. All buildings and infrastructure are built on or in the soil, so it's important to investigate and consider soil characteristics for land use planning.

This publication describes the causes of shrinking and swelling in soils, shows the distribution of soils most likely to shrink and swell in Indiana, and relates this problem to septic system performance.

Clay Minerals

Oxygen, silicon, and aluminum are the three most abundant elements in the earth's crust. These elements make up the structure of many clay minerals. There are many types of clay minerals, each with different chemical and physical properties that affect the behavior of the soils where they exist. The type and proportion of clay minerals present in a soil depend on the soil's parent material.

Most of the clay minerals found in Indiana are layer silicates. Layer silicates are made up of sheets stacked on top of one another (like a deck of cards), bonded together. A tetrahedral sheet is made up of silicon-oxygen tetrahedrons bonded together that share basal oxygens (Figure 1). An octahedral sheet is made up of aluminum-oxygen octahedrons bonded together that share apical and basal oxygens (Figure 1). These tetrahedral or octahedral sheets bond together through hydrogen bonding (sharing of electrons), and form layers.

Clay minerals formed by the bonding together of one tetrahedral sheet and one octahedral sheet are called 1:1 clay minerals. These clay minerals are the most simple. They are electrically neutral (i.e., they have no charge, therefore they will not attract positively or negatively charged soil nutrients or contaminants) and do not shrink or swell with the wetting and drying cycles of a soil. These clay minerals, although found worldwide, are especially common in very weathered, old soils (such as in South America or Africa). Examples of these structures are shown in Figure 2.

Clay minerals formed by the bonding together of two tetrahedral sheets and one octahedral sheet are called 2:1 clay minerals. These structures are more complicated and tend to be more active. Due to ion substitution in the layers, some of these clay minerals have a negative charge on the surface and will attract water or hydrated cations (ions with a positive charge surrounded by water molecules). Because of this, 2:1 clay minerals have the potential to shrink and swell. These clay minerals are generally found in young to medium-aged soils that haven't experienced extensive weathering (such as in the glaciated region of the United States). Examples of these structures are also shown in Figure 2.

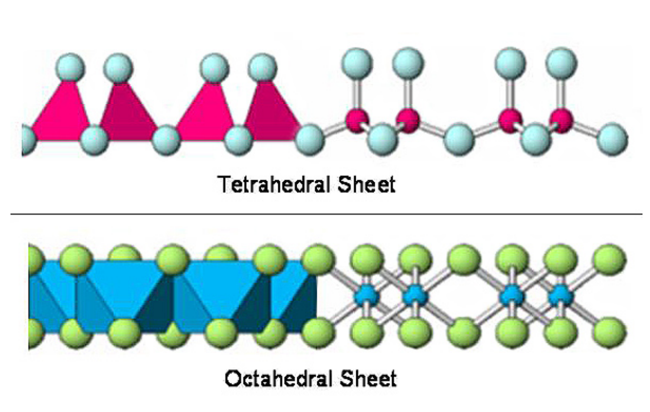

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Figure 1. *In these models of tetrahedral and octahedral sheets, the light blue balls in the tetrahedral sheet and light green balls in the octahedral sheet represent oxygen. Red triangles/balls in the tetrahedral sheet represent silicon, and dark blue triangles/balls in the octahedral sheet represent aluminum.*

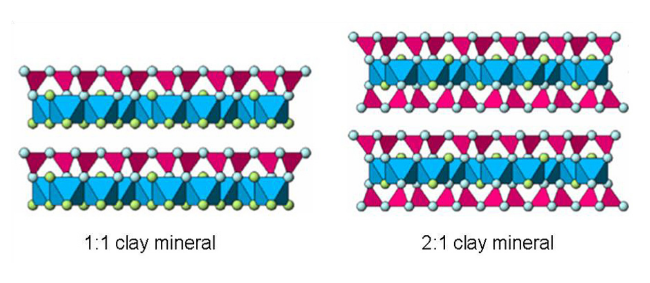

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Figure 2. *The illustration on the left shows a 1:1 clay mineral structure. The illustration on the right shows a 2:1 clay mineral structure.*

When soils are moist, the negatively charged surfaces of 2:1 clay minerals attract positively charged water molecules, allowing the water to enter between the layers (Figure 3). Water in between the layers causes the clay structure to expand, causing the whole soil to expand. When the soil dries, the water trapped between the clay mineral layers is released, causing the whole soil to "shrink."

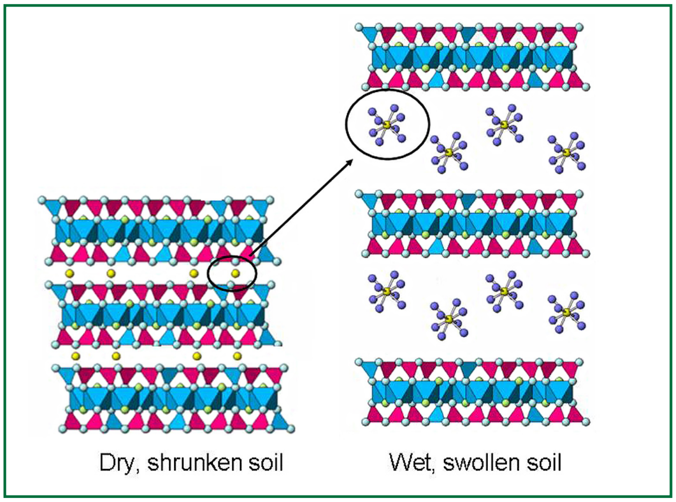

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Figure 3. *Cation hydration can expand 2:1 clay mineral silicates when the soils are wet. Cations are represented by the yellow circles in between the clay layers in the dry soil. When water bonds to the cation in the clay layer, the cation becomes hydrated. The newly hydrated cation has a larger ionic radius and the clay layers expand to accommodate the larger size.*

Phillip Owens

Figure 4. *Surface cracks are good indicators of a soil that is prone to swelling and shrinking. Marks on the tape are approximately 4 inches apart.*

Why Do Some Soils Shrink and Swell?

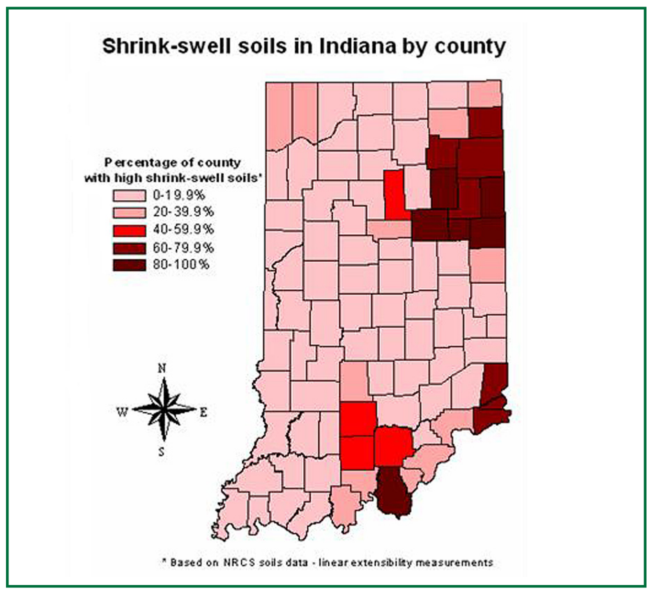
Soils shrink and swell depending on the expansive characteristics of certain clay-sized minerals that are less than 0.002 mm in diameter. One family of these clay minerals, smectites, can absorb enough water to expand up to 30 percent in volume. Montmorillonite is a common clay mineral in this family. Because expansion of these clay minerals depends so much on water, soils containing high amounts of smectites shrink and swell according to soil moisture. As one might expect, the greatest swelling and shrinking occurs in climates that have distinct wet and dry seasons.

During dry seasons, it is easy to identify soils with a high shrink and swell potential. These soils will have large cracks on the surface due to the shrinking of the clay minerals (Figure 4). When the soil becomes wet again, the cracks will shrink or disappear.

Expansive Minerals in Indiana Soils

Smectite-dominated soils tend to hold more water and drain more slowly than soils with less expansive minerals or soils with little clay. Smectite clays have a greater shrink-swell capacity than any other soil minerals found in Indiana and are the likely cause for most of the shrinking and swelling soils found here. Most of these soils are found in the northeastern and southern areas of the state (Figure 5).

If you are developing a home lot in a county with a large percentage of high shrink-swell soils, and believe your soils have shrink-swell characteristics, consult a registered professional soil scientist.



Map constructed using Indiana STATSGO data

Figure 5. *This map shows the percentage of soils with high shrink-swell potential found in Indiana counties.*

Septic System Performance Impacts

Because septic systems rely on the natural soil to filter wastewater, they are directly affected by soil properties. Soil texture and structure, as well as mineralogy, can influence septic system performance.

When wet conditions cause clay minerals to expand, wastewater infiltration in the soil below the septic system's soil absorption field may decrease. When the soil minerals swell, the pore space in the soil decreases, restricting water movement. Septic system drainage fields will be moist as long as a house is occupied, so expanding clay minerals in the soil could severely restrict wastewater flow into the soil and cause the septic system to fail by effluent surfacing.

Under current Indiana septic system rules (Indiana State Department of Health Rule 410 IAC 6-8.1, see http://www.in.gov/isdh/regsvcs/saneng/

laws_rules/410_iac_6-8_1/410_iac_6-8_1.htm), determining a soil's shrink-swell potential is not required during the soil evaluation for a septic system permit. So, while a soil can pass the required inspection for a septic system, the soil can still lead to system failure, resulting in thousands of dollars in unnecessary costs.

What Can Be Done?

The best way to deal with high shrink-swell clays is to observe the soil surface during dry periods and identify any large cracks that appear. A soil survey also should contain the coefficient of linear extensibility (COLE) value of the soils on the site. If a soil has a COLE value of 0.06, then 100 inches of dry soil will expand by 6 inches when wet. Soil with COLE values greater than 0.06 can cause structural damage.

Soil surveys are created and maintained by the USDA-Natural Resource Conservation Service (USDA-NRCS). For more information about surveys and soils in your area, contact your local USDA-NRCS service center (find a local service center at http://offices.sc.egov.usda.gov/locator/app), or use the National Cooperative Soil Survey's Web Soil Survey (available online http://websoilsurvey.nrcs.usda.gov/app/). The Web Soil Survey is a simple and powerful way to access and analyze soil data.

Consult a professional soil scientist if you suspect your lot contains soil with high shrink-swell potential. A list of Indiana Registered Soil Scientists (IRSS) and instructions on how to obtain their services are available at www.isco.purdue.edu/irss/obtaining_services.htm. County health departments also will have a list of soils professionals who work in their counties. Professional soil scientists can take a soil sample and have it analyzed for shrink-swell potential upon request. Knowing the soil's shrink-swell potential will help to dictate what kind of septic system should be installed at a site, and may help prevent costly repairs in the future.

Other Purdue Extension bulletins in this series

RW-1-W, *High Water Tables and Septic System Perimeter Drains*, www.ces.purdue.edu/extmedia/RW/RW-1-W.pdf

RW-2-W, *Soil Hydraulic Conductivity and Septic System Performance*, www.ces.purdue.edu/extmedia/RW/RW-2-W.pdf

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