SOILS ARE IMPORTANT TO SOUTH DAKOTA: (2) HOW DO SOILS FORM?

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How Do Soils Form?

Soils develop through a series of changes. The starting point is freshly accumulated parent material. Weathering processes release simple compounds that serve as food for bacteria, fungi, and other soil organisms. Dead soil organisms decay in the parent material causing organic matter (humus) to accumulate. Gradually, the developing soil is able to support higher forms of plant and animal life. The present level of humus in our soils is due principally to the activity of higher forms of plant life. Upper layers of the loose parent material at the Earth's surface accumulate humus from dead plant material. The soil pH becomes reduced and leaching takes place. Leaching is the removal of materials in solution from the soil by percolating waters. These changes form distinctive soil layers called horizons.

There are four types of processes involved in horizon development. A soil horizon is a layer of soil parallel to the soil surface that had distinct properties from the adjacent layers. Additions to the soil come from precipitation, organic matter, and solar energy. Losses are processes that often are destructive, such as erosion, leaching of nutrients, night radiation of energy, nitrogen losses by microbial activity, and water loss through plant transpiration. Movement of materials within the soil occurs through nutrient cycling by plants and soil mixing by organisms. Lastly, new compounds are formed within soil from weathered rocks and minerals and organic material.

What Soil Horizons Are Found In South Dakota?

Soils vary in the types and number of horizons present. Very young soils may have only one or two soil horizons present. The soils in SD are relatively young.

Soil horizons are identified or described by standard symbols (i.e. ‘A’, ‘B’, ‘k’, ‘w’, ‘t’, and many others). Each symbol shows how the material has been altered when compared to the original parent material. Most master soil horizons have only one capital letter (i.e. ‘A’, ‘B’, ‘C’, ‘E’, ‘O’, and ‘R’) but some require two (i.e. ‘AB’, ‘EB’, ‘AC’, ‘BC’, ‘EB’, and others) if the layer is mixed or composed of two major horizons or is a transitional layer. Two different soil profiles with the different horizons identified are shown in Figure 1.

Figure 1. The soil type shown above is HOUDEK which is the State Soil of SD. Horizons present: 1.   'A' horizon (0 - 7 inches);   2. 'Bt' horizon (7 - 15 inches); 3. 'Bk' horizon (15 – 36 inches); 4. 'C' horizon(36+).

An 'O' horizon is a layer dominated by organic materials (i.e. leaves, needles, twigs, moss, and other un-decomposed or partially decomposed plant litter). 'O' horizons are common in forest derived and saturated, wetland soils. Organic matter content in 'O' horizons commonly exceeds 35 %.

An 'A' horizon is a mineral horizon that is high in humus (1-10 %) or shows the influence of cultivation, grazing, or similar agricultural disturbance. Usually, the 'A' horizon is called "topsoil". 'A' horizons are usually found at the soil surface but can be found below an 'O' horizon. An 'A' horizon that is cultivated is called an 'Ap' horizon.

A ‘B’ horizon is a mineral layer that forms beneath an ‘A’, ‘E’, or ‘O’ horizon. ‘B’ horizons are sometimes referred to as the "subsoil". It represents a layer where there has been either a significant gain of clay (‘Bt’), humus (‘Bb’), salts (‘Bk’, ‘By’, or ‘Bz’) or iron/aluminum oxides or change in soil color and structure (‘Bw’).

A ‘C’ horizon is a mineral horizon that is usually found beneath ‘O’, ‘A’, ‘B’, or ‘E’ horizons. ‘C’ horizons are soil layers that are little changed. ‘Cr’ horizons are composed of soft bedrock that can be dug with a spade (i.e. shale, siltstone, weathered sandstone). The ‘C’ horizon is often called the "parent material".

The ‘E’ horizon is a mineral horizon where significant loss of clay, humus and/or iron/aluminum oxides has resulted in a lighter colored and coarser textured layer than the layers above or below. ‘E’ horizons occur above ‘B’ horizons and are found at or near the soil surface. ‘E’ horizons are most commonly found in forest derived, sodium affected, or depression soils.

The ‘R’ horizon is hard bedrock that cannot be dug with a spade. Examples of hard bedrock present in SD include granite, limestone, and sandstone. This horizon does not exhibit evidence of soil genesis or weathering.

Lower case letters (e.g. b, g, t, w, and many others) are used to further define the properties of the layer. If a layer needs to be subdivided, then numbers are used. Discussion of further soil naming can be found in the soil survey manual: USDA – Soil Survey Division Staff, 1993.

Soil horizons are identified by collecting and analyzing soil cores from different areas in fields. The soil cores that are collected are usually deeper than what can be collected with a hand probe. Therefore a soil probe mounted on a tractor or truck is usually used to collect the sample (Figure 2). The soil properties (for example, color, reaction to weak acid, etc) in the core are analyzed to determine the depths of the different horizons (Figure 3).

Figure 2. Collecting a soil core with a tractor probe to analyze soil horizons.

Figure 3. Analyzing a soil sample to determine different horizons.

Conservation Measures

Protecting soil quality is critical to the welfare of our people and our economy. There are four major concerns in soil conservation: loss of moisture; loss of organic matter and nitrogen; loss of mineral nutrients; and loss of topsoil through erosion.

Moisture loss occurs through evaporation, transpiration, leaching, and runoff. Evaporation and runoff are particularly serious when water does not quickly soak into the soil. Water will move more quickly through sandy soils as compared to clay soil. Additions of organic matter to the soil assist with water uptake and storage. Other solutions include leaving stubble in the fields through minimum till or no-till practices. Moisture loss through weed transpiration can also be significant. Weed reduction can be accomplished through applying herbicides, cultivation and crop rotations.

Organic matter and nitrogen loss from soils can seriously reduce crop yields and make soils more susceptible to erosion. South Dakota soils have lost about 30 to 50% of their original organic matter and organic nitrogen as a result many years of tillage. Nitrogen can be returned to the soil through application of natural waste products, commercial organic and inorganic fertilizers, or through the planting of nitrogen-fixing plants, such as alfalfa or clover. No-till or minimum tillage methods allow for organic matter to build up more quickly as compared to conventional till methods like moldboard or chisel plow.

Mineral nutrient losses due to erosion varies from one nutrient to another. Nutrients such as potassium, calcium, and magnesium are usually present in adequate amounts in South Dakota soils. Phosphorus content, however, is low in most soils of the state, and is highest in topsoil, which is lost in erosion. Phosphorus can be returned to the soil by adding waste products and commercial fertilizers.

Soil loss from erosion can be caused by the action of wind and/or water. Soil texture, soil structure, slope of the land, and the amount of plant cover affect the amount of soil erosion that can occur. Soil blowing can be reduced through conservation tillage that keeps a growing crop or plant residues on the land throughout the year. No-till or minimum till are a conservation tillage strategies where the soil is disturbed only in the immediate area of the planted seed row. Another method to reduce wind erosion is to plant shelterbelts. Retaining soil also increases the water and nutrient storage and increase microbial activity. Water erosion from runoff can be reduced through residue management, terracing, contour tillage and contour strip cropping, all of which lessen the impact of land slope.

Further information about the USDA Soil Survey can be obtained at: http://www.statlab.iastate.edu/soils/index.html/.

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