UNIT – III

ROCK:

Defining and Rock Types: There are three types of rocks: ***igneous, sedimentary and metamorphic.*** Each of these types is part of the rock cycle. Through changes in conditions one rock type can become another rock type. Or it can become a different rock of the same type.

A rock is a naturally formed, non-living earth material. Rocks are made of collections of mineral grains that are held together in a firm, solid mass. How is a rock different from a mineral? Rocks are made of minerals. The mineral grains in a rock may be so tiny that you can only see them with a microscope, or they may be as big as your fingernail or even your finger.

Rocks are identified primarily by the minerals they contain and by their texture. Each type of rock has a distinctive set of minerals. A rock may be made of grains of all one mineral type, such as quartzite. Much more commonly, rocks are made of a mixture of different minerals. Texture is a description of the size, shape, and arrangement of mineral grains.

Rocks are classified into three major groups according to how they form. Rocks can be studied in hand samples that can be moved from their original location. Rocks can also be studied in outcrop, exposed rock formations that are attached to the ground, at the location where they are found.

Igneous rocks form from cooling magma. Magma that erupts onto Earth's surface is lava. The chemical composition of the magma and the rate at which it cools determine what rock forms as the minerals cool and crystallize. Sedimentary rocks form by the compaction and cementing together of sediments, broken pieces of rock-like gravel, sand, silt, or clay. Those sediments can be formed from the weathering and erosion of preexisting rocks. Sedimentary rocks also include chemical precipitates, the solid materials left behind after a liquid evaporates. Metamorphic rocks form when the minerals in an existing rock are changed by heat or pressure within the Earth.

Crystallization: Magma cools either underground or on the surface and hardens into an igneous rock. As the magma cools, different crystals form at different temperatures, undergoing crystallization. For example, the mineral olivine crystallizes out of magma at much higher temperatures than quartz. The rate of cooling determines how much time the crystals will have to form. Slow cooling produces larger crystals.

Erosion and Sedimentation: Weathering wears rocks at the Earth's surface down into smaller pieces. The small fragments are called sediments. Running water, ice, and gravity all transport these sediments from one place to another by erosion. During sedimentation, the sediments are laid down or deposited. In order to form a sedimentary rock, the accumulated sediment must become compacted and cemented together.

When a rock is exposed to extreme heat and pressure within the Earth but does not melt, the rock becomes metamorphosed. Metamorphism may change the mineral composition and the texture of the rock. For that reason, a metamorphic rock may have a new mineral composition and/or texture.

A. Igneous Rocks:

Igneous rocks form from the cooling and hardening of molten magma in many different environments. These rocks are identified by their composition and texture. More than 700 different types of igneous rocks are known.

Magma Composition: Advancing Pahoehoe toe, Kilauea Hawaii 2003The rock beneath the Earth's surface is sometimes heated to high enough temperatures that it melts to create magma. Different magmas have different composition and contain whatever elements were in the rock that melted. Magmas also contain gases. The main elements are the same as the elements found in the crust. Whether rock melts to create magma depends on:

Temperature: Temperature increases with depth, so melting is more likely to occur at greater depths.

Pressure: Pressure increases with depth, but increased pressure raises the melting temperature, so melting is less likely to occur at higher pressures.

Water: The addition of water changes the melting point of rock. As the amount of water increases, the melting point decreases.

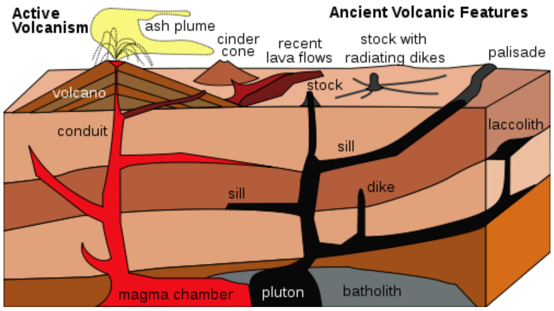
Rock composition: Minerals melt at different temperatures, so the temperature must be high enough to melt at least some minerals in the rock. The first mineral to melt from a rock will be quartz (if present) and the last will be olivine (if present).

The different geologic settings that produce varying conditions under which rocks melt will be discussed in the "Plate Tectonics" chapter. As a rock heats up, the minerals that melt at the lowest temperatures will melt first. Partial melting occurs when the temperature on a rock is high enough to melt only some of the minerals in the rock. The minerals that will melt will be those that melt at lower temperatures. Fractional crystallization is the opposite of partial melting. This process describes the crystallization of different minerals as magma cools.

Bowen's Reaction Series indicates the temperatures at which minerals melt or crystallize. An understanding of the way atoms join together to form minerals leads to an understanding of how different igneous rocks form. Bowen's Reaction Series also explains why some minerals are always found together and some are never found together.

If the liquid separates from the solids at any time in partial melting or fractional crystallization, the chemical composition of the liquid and solid will be different. When that liquid crystallizes, the resulting igneous rock will have a different composition from the parent rock.

A schematic geological cross-section of a sequence of sedimentary rocks that are later intruded by igneous rocks accompanied by volcanic activity.



Intrustive Igneous Rock: PictureIgneous rocks are called intrusive when they cool and solidify beneath the surface. Intrusive rocks form plutons and so are also called plutonic. A pluton is an igneous intrusive rock body that has cooled in the crust. When magma cools within the Earth, the cooling proceeds slowly. Slow cooling allows time for large crystals to form, so intrusive igneous rocks have visible crystals. Granite is the most common intrusive igneous rock.Igneous rocks make up most of the rocks on Earth. Most igneous rocks are buried below the surface and covered with sedimentary rock, or are buried beneath the ocean water. In some places, geological processes have brought igneous rocks to the surface. Yosemite is a classic example of intrusive igneous rock. The molten magma never reached Earth's surface, so the molten material had millions of years to cool down slowly to form granite. Later, geologic forces and erosion have caused those granite plutons to surface as they are today.

Extrusive Igneous Rock: Lava entering the sea, expanding the big island of Hawaii.Igneous rocks are called extrusive when they cool and solidify above the surface. These rocks usually form from a volcano, so they are also called volcanic rocks. Extrusive igneous rocks cool much more rapidly than intrusive rocks. There is little time for crystals to form, so extrusive igneous rocks have tiny crystals.Cooling rate and gas content create a variety of rock textures. Lavas that cool extremely rapidly may have a glassy texture. Those with many holes from gas bubbles have a vesicular texture.

Human Use of Igneous Rock: Igneous rocks have a wide variety of uses. One important use is as stone for buildings and statues. Granite is used for both of these purposes and is popular for kitchen countertops. Pumice is commonly used as an abrasive. Pumice is used to smooth skin or scrape up grime around the house. When pumice is placed into giant washing machines with newly manufactured jeans and tumbled, the result is "stone-washed" jeans. Ground up pumice stone is sometimes added to toothpaste to act as an abrasive material to scrub teeth. Peridotite is sometimes mined for peridot, a type of olivine that is used in jewelry. Diorite was used extensively by ancient civilizations for vases and other decorative artwork and is still used for art today.

B. Sedimentary Rocks: Inside Lower Antelope Canyon, featuring red sandstone corridors.

Sandstone is one of the common types of sedimentary rocks that form from sediments. There are many other types. Sediments may include: fragments of other rocks that often have been worn down into small pieces, such as sand, silt, or clay. organic materials, or the remains of once-living organisms. chemical precipitates, which are materials that get left behind after the water evaporates from a solution.

Rocks at the surface undergo mechanical and chemical weathering. These physical and chemical processes break rock into smaller pieces. Physical weathering simply breaks the rocks apart. Chemical weathering dissolves the less stable minerals. These original elements of the minerals end up in solution and new minerals may form. Sediments are removed and transported by water, wind, ice, or gravity in a process called erosion.

Streams carry huge amounts of sediment. The more energy the water has, the larger the particle it can carry. A rushing river on a steep slope might be able to carry boulders. As this stream slows down, it no longer has the energy to carry large sediments and will drop them. A slower moving stream will only carry smaller particles.

Sediments are deposited on beaches and deserts, at the bottom of oceans, and in lakes, ponds, rivers, marshes, and swamps. Avalanches drop large piles of sediment. Glaciers leave large piles of sediments, too. Wind can only transport sand and smaller particles. The type of sediment that is deposited will determine the type of sedimentary rock that can form. Different colors of sedimentary rock are determined by the environment where they are deposited. Red rocks form where oxygen is present. Darker sediments form when the environment is oxygen poor.

Sedimentary Rock Formation: Inside Lower Antelope Canyon, looking out with the sky near the top of the frame. Characteristic layering in the sandstone is visible.Accumulated sediments harden into rock by a process called lithification. Two important steps are needed for sediments to lithify.

Sediments are squeezed together by the weight of overlying sediments on top of them. This is called compaction. Cemented, non-organic sediments become clastic rocks. If organic material is included, they are bioclastic rocks.

Fluids fill in the spaces between the loose particles of sediment and crystallize to create a rock by cementation.

When sediments settle out of calmer water, they form horizontal layers. One layer is deposited first, and another layer is deposited on top of it. So each layer is younger than the layer beneath it. When the sediments harden, the layers are preserved. Sedimentary rocks formed by the crystallization of chemical precipitates are called chemical sedimentary rocks.

Biochemical sedimentary rocks form in the ocean or a salt lake. Living creatures remove ions, such as calcium, magnesium, and potassium, from the water to make shells or soft tissue. When the organism dies, it sinks to the ocean floor to become a biochemical sediment, which may then become compacted and cemented into solid rock.

Human Use of Sedimentary Rock: Sedimentary rocks are used as building stones, although they are not as hard as igneous or metamorphic rocks. Sedimentary rocks are used in construction. Sand and gravel are used to make concrete; they are also used in asphalt. Many economically valuable resources come from sedimentary rocks. Iron ore and aluminum are two examples.

C. Metamorphic Rock: Metamorphism is the addition of heat and/or pressure to existing rocks, which causes them to change physically and/or chemically so that they become a new rock. Metamorphic rocks may change so much that they may not resemble the original rock. Any type of rock—igneous, sedimentary, or metamorphic—can become a metamorphic rock. All that is needed is enough heat and/or pressure to alter the existing rock's physical or chemical makeup without melting the rock entirely. Rocks change during

Metamorphism because the minerals need to be stable under the new temperature and pressure conditions. The need for stability may cause the structure of minerals to rearrange and form new minerals. Ions may move between minerals to create minerals of different chemical composition. Hornfels, with its alternating bands of dark and light crystals, is a good example of how minerals rearrange themselves during metamorphism.

Extreme pressure may also lead to foliation, the flat layers that form in rocks as the rocks are squeezed by pressure. Foliation normally forms when pressure is exerted in only one direction. Metamorphic rocks may also be non-foliated. Quartzite and limestone are nonfoliated. The two main types of metamorphism are both related to heat within Earth:

Regional metamorphism: Changes in enormous quantities of rock over a wide area caused by the extreme pressure from overlying rock or from compression caused by geologic processes. Deep burial exposes the rock to high temperatures.

Contact metamorphism: Changes in a rock that is in contact with magma because of the magma's extreme heat.

Quartzite is very hard and is often crushed and used in building railroad tracks. Schist and slate are sometimes used as building and landscape materials. Graphite, the "lead" in pencils, is a mineral commonly found in metamorphic rocks.

WEATHERING:

I. Definition

Rock weathering may be defined as the disintegration and decomposition of rock place or in situ.

II. Factors Controlling Weathering

A number of factors control weathering important among them are;

i. Rock Structure
ii. Climate
iii. Vegetation
iv. Topography/Slope
v. Time

III. Types of Weathering

Depending upon the process weathering may be divided into two broad type.

i. Physical or Mechanical weathering
ii. Chemical weathering

i. Physical or Mechanical weathering

The disintegration of rock into pieces without chemical change is called physical or mechanical weathering. It is done by number of processes. Some of them;

a) Unloading of Pressure
b) Thermal effect
c) Freezing or melting or water
d) Action of plant and animals

a) Unloading of Pressure

During ice age large area was cover with thick ice. During warm period glaciers melted and retreated this resulted in the removal of pressure on the surface rock. Because of this is slide expansion of the surface rock which creates number of crakes on the surface. This weakents of the rock a broken it is pieces. This process of development of creaks due to unloading of pressure is called spalling.

b) Thermal effect

Rock some time has minerals with different colors. Dark color minerals absorbed and release heat quickly. Similarly light color minerals absorb and release heat slowly. During day time in area like a deserts temperature are very high. Because of this the dark minerals become very hot and expand more, while light color minerals expand less. During night the cold condition makes dark color minerals to contract more and light color minerals to contract less. Such differential rates of contraction and expansion need to the breaking of rock into grains. Such a type of weathering is called granular weathering.

Griggs made a laboratory experiment taking a piece of rock and exposing it to alternate cycles of heat & cold. He found that even after repeating a few thousands of times there was no sign of the rock of any weakness. However the some rock developed minor rocks when the process was done with some moisture in the rock. It indicated that near thermal effect may not be breaking the rock. However it cannot also the accepted because actual condition may bring different effect than that of laboratory conditional.

c) Breezing and Melting of Water

This is a process which is mostly found in higher middle latitude of higher altitudes. In these areas during some parts of the year temperatures go below breezing point during night and is above breezing point during day time. If water gets collected in cracks or join in this area it breezes into ice during night. When waters breezes to ice it increases in volume by 9%. Therefore the frozen ice puts pressure on either side of the crack or the join. Next day warmer condition melts the ice and the pressure is less next night again water breezes into ice and put pressure. Does alternative breezing and melting of water make the crake or join wider and finally the rock brakes into a number of rocks there is called block disintegration or Frost disintegration.

d) Action of Plant and Animals

Biological activities may also bring physical weathering. Birds may leave the seed of plant in the rock. Which geminate into plants. If the plants or small the joints are not affected much. But when plant grows, the stem becomes thick widening the joints and breaking the rock.

ii. Chemical Weathering

When a rock undergoes change in the chemical composition after weathering, it is called chemical weathering. Here decomposition is the process water is essential for chemical reaction. Therefore without water no chemical weathering is possible.

Chemical weathering takes place through a number of processes. Some of them are;

a) Oxidation
b) Carbonation

c) Solution
d) Hydraction
e) Hydralicis

a) Oxidation

It is the process by which oxygen is added to chemical composition. A comparatively stronger rock may become weaken after oxidation making removal easier.

Example: Ferrous Oxide + Oxygen + Water = Ferric Oxide (Rust)

$$FeO_2 \quad + \quad O_2 \quad + \quad H_2O \quad = \quad Fe_2O_3$$

Iron is a very common mineral in the form of ferrous oxide with interacts with oxygen and water in the atmosphere and becomes ferric oxide or rust it is weaker and easily removable.

b) Carbonation

Here carbon dioxide added to the mineral composition. This makes the original resistant mineral into a change weaker mineral.

Example: Calcium Carbonate + Carbon Dioxide + Water = Calcium Bicarbonate

$$CaCo_3 \quad + \quad Co_2 \quad + \quad H_2O \quad = \quad CaHCo_3$$

Calcium Carbonate or lime stone is a very common type of rock it is not solivable in water. But when it interacts with carbon dioxide and water in the atmosphere it is converted into calcium bicarbonate which is solivable mineral. Thus a comparatively stronger rock becomes weak after carbonation.

c) Solution

Rocks have minerals which may be solivable or in solivable in water. A rock with insolivable mineral is stringest and a rock with solivable mineral is weaker. Solution is the process in which an insolivable mineral in the rock converted a solivable mineral after chemical reaction.

d) Hydraction

In this process water molecule is added to chemical structure after mineral making it weaker. For example when water molecule is added to unhydred it is converted into Gypsem, which is a weaker mineral.

e) Hydralicis

Most of the rocks have silicon and alumina or clay as the major minerals. Hydrolisis is the process by which stronger silica is removed leading more clay which is weaker clay.

In addition to these major process. We also have other minor chemical process like chelation. Base exchange were changes are micro scopic in nature.

Other Types of Weathering

Some special mention is to be made for one or two types of weathering. They are;

i. Expoliation
ii. Spheroidal

MASS WASTING:

I.Definition

Mass movement or mass wasting is the down slope movement of weathered material mainly due to gravity. Sometimes water or moisture helps this movement as lubricants.

II. Factor

A number of factors affect mass movement. It is possible to divide these factors into two groups namely passive factor and active factor.

i. **Passive Factor:** These are the factor where condition to not change much for example rock structure and climate are passive factors. Both this decide the rate and type of weathering their by controlling if amount of weathered material. These passive factors therefore control mass movement which depends also on the quantitative.
ii. **Active Factor :** Here the conditions of the factors change and mass movement becomes easier after this change. For example two processes may be given.

a) **Steepening of the Slope:** The slope of the region may be modified by other processes like erosion. Some times a gentle slope becomes steeper especially at the space due to erosion. Because of change of slope mass movement become easier.
b) **Removal of Support:** Sometimes a rock or vegetative cover mainly blocking the down slope movement of weathered material. Removal of such blocks or supports makes mass movement easier.

III. Types of Mass Movement

Depending upon the speed, mass movement is generally divided into two major types. They are;

i. Slow movement or creep
ii. Rapid or sudden movement. This is further sub divided into either fall or flow movements.

i. Slow Movement

There are three types of slope movement. There are; ***a). Soil Creep, b), Rock or Debris Creep and c), Soil Fluction.***

i. **Soil Creep:** It is the down slope movement of top soil due to gravity, It is invisible, It can be identified by the bending of tree

a) **Rock or Debris Creep:**When the two layer covered by broken particles of rock they called debris. The slope, down slope movement of this debris is called debris creep.

b) **Soil Fluction:** It is similar to soil creep but the difference is that here the soil is saturated.

ii. Rapid or Fast Movement

A number of types may be identified under mass movement with rapid displacement some of them are; ***a). Rock Fall, b). Debris Fall, c). Earth Flow and Mud Flow, d). Slump, e). Land Slide***

a) Rock Fall: When bigger pieces of rock fall due to gravity it is called rock fall generally this occurs with exploitation process where part of the layer attach with main rock falls down.

b) Debris Fall: When loose unconsolidated materials fall down along a slope it is called debris fall. Usually collection of water in between the pieces of rock increases the total weight making debris unstable.

c) Earth Flow and Mud Flow: When saturated soils move down rapidly it is called either earth flow or mud flow. Usually mud flow is continued to a channel why earth flow covers the entire slope.

d) Slump:

1. It is a special form of earth flow
2. It generally occurs in valley

When earth flow from on slope reaches the bottom of valley it is forced to rise on the other slope. But gravity pushes it back to the valley bottom. This creates a backward rotative movement on the original slope. This process is called slump.

e) Land Slide: It is the most common type of mass movement. Here the entire slopes slide down with rock, vegetation, soil etc. A number of conditions help landslides.

1. Large amount of loose or unconsolidated materials.
2. Heavy rainfall or snow fall
3. Steep slope
4. Lack of vegetation cover

Landslides occur mostly in the some region. Human activity like deforestation and road construction in the hill also lead to land slide.

SOILS:

I. Definition

Soil may be defined as the upper most superficial layer of loose unconsolidated material above Cristal rock or which plants may grow. Soils are significant because they are essential for plant growth. Without plants food product is not possible and living things cannot be survive.

II. Constituents of Soil

Soil constituents are broadly grouped into two types;

i. Inorganic constituents
ii. Organic constituents

Inorganic constituents include soil air, soil water, soil mineral etc. In case organic constituents will have macro organism like insects, moths, beetle worms, ants etc. We also have millions of micro organism like bacteria sometimes soil also have "humus" which is a soft jelly like substance made up of decomposed organic matter. This is usually black or dark brown in colors.

III. Factors Affecting the Soil Formation

Various factors affecting soil formation and quality. Important among them are, i. Rock Structure, ii. Climate, iii. Vegetation, iv, Topography and v. Time.

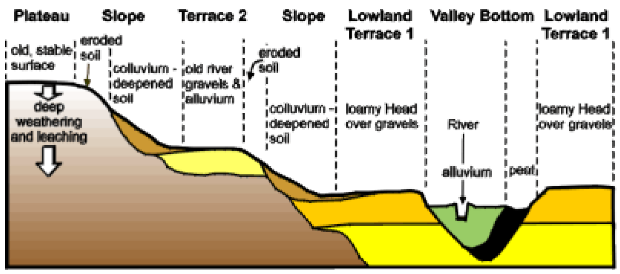
i. Rock Structure: It is most important factor in soil formation since rock is the parent material. The chemical composition of rock decides the quality of soil. Further adjoined rocks breaks down quickly and so soil thickness is comparatively more. A rock without joints disintegrate slowly and has thinner in soil. Even though rock structure is important in soil formation. The quality of soil depend upon other factors also. For example some rock may produced different type of soil under different climates. Similarly nature of soil on the same rock various between vegetative areas and barren lands.

ii. Climate: Another important factor deciding soil fertility. In wet climate water removes mineral like calcium carbonate while in dry climate soil are rich in time.

iii. Vegetation: Presence/absence of vegetation also affects soil formation and quality. In between lands soil erosion will be more and so we have thin soil or the other land it checked. Further presence of vegetation increase the organic content of soil making it more fertile.

iv. Topography: The nature of slope yet another factor affecting soil formation. In steep slopes soil removed is thicker and hence we have thin soil. On the other hand in gentle slope comparatively thicker soil found.

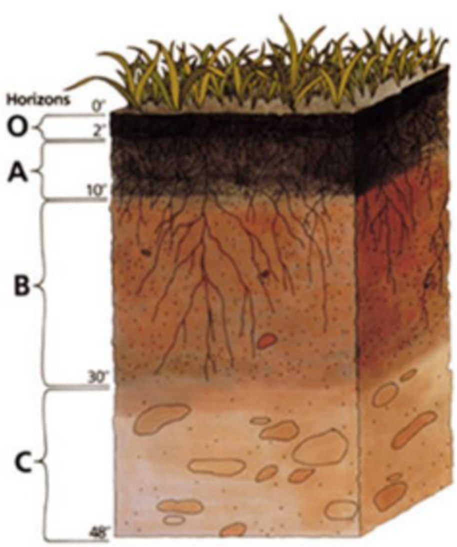
- **v. Time :** Since soil formation depends upon the time factor. The nature of soil various from one are to another. Rock which is exposed for hundreds of years may have mature soil with different composition. On the other hand young soil show different characteristics particularly in soil profile.



It is important to realise also that soil types are closely related to the shape of the landscape - or its 'topography'. Soil scientists use this to help them create soil maps. An experienced eye can determine changes in underlying soil types when walking through a landscape and observing changes in topography (and often vegetation too).

The relationship of soil and topography.

IV. Soil Profile:



If you look in a soil pit or on a roadside cut, you will see various layers in the soil. These layers are called soil horizons. The arrangement of these horizons in a soil is known as a soil profile. Soil scientists, who are also called pedologists, observe and describe soil profiles and soil horizons to classify and interpret the soil for various uses.

Soil horizons differ in a number of easily seen soil properties such as color, texture, structure, and thickness. Other properties are less visible. Properties, such as chemical and mineral content, consistence, and reaction require special laboratory tests. All these properties are used to define types of soil horizons.

Soil scientists use the capital letters O, A, B, C, and E to identify the master horizons, and lowercase letters for distinctions of these horizons. Most soils have three major horizons -- the surface horizon (A), the subsoil (B), and the substratum (C). Some soils have an organic horizon (O) on the surface, but this horizon can also be buried. The master horizon, E, is used for subsurface horizons that have a significant loss of minerals (eluviation). Hard bedrock, which is not soil, uses the letter R.

V. Conservation:

Soil conservation is an important part of conservation cropping systems. There are many benefits for producers who choose to employ soil conservation practices on-farm.

Increased Profits: 1. Yields are equal to or greater than traditional tillage. 2. Reduce use of fuel and labor. Requires less time. 3. Lower machinery repair and maintenance costs.4. Potential reduction in fertilizer and herbicide costs.

Improved Environment: *Improved soil quality and productivity, Reduced erosion, Increased water infiltration and storage, Improved air and water quality, Provides food and shelter for wildlife.*

Properties of a Healthy Soil: *High organic matter content, Optimal nutrients and pH for plant growth, Stable aggregates to promote water infiltration, Large population of beneficial organisms, No compaction layers, No contamination.*

Many soils in Alabama have low levels of soil organic matter due to the warm climate, coarse-textured soils and intensive farming practices historically used in the state. Rebuilding soil health is important! Soil is a natural resource we must work to conserve for future generations. Practices such as reduced tillage and cover cropping can increase organic matter and improve soil health. There are several important ways producers can improve soil health.

Practices to Improve Soil Health

- Provide a cover to the soil. Bare soil is susceptible to wind and water erosion. Cover crops help protect soil from erosion and helps to build soil organic matter when cash crops are not actively growing. Cover crops can also supply plant nutrients, regulate soil temperature, improve soil structure, and suppress weeds.

- Disturb soil less. Tillage disrupts soil aggregates and increases risk of soil compaction. (Soil aggregates are groups of soil particles which are more strongly bound to one another than adjacent soil particles.) Stable soil aggregates help to prevent soil erosion. Aggregates also provide pore space for water and air to enter the soil, allowing plant roots to grow.) Compaction can hinder root growth and decrease production on agricultural soils. Tillage also speeds up the breakdown of soil organic matter. Reducing tillage can help prevent runoff, increase soil organic matter, and reduce erosion.

- Increase plant diversity. Different plants can provide a variety of different benefits to the soil. Increasing plant diversity through crop rotation can also help break pest cycles.

- Keep an active crop growing. Actively growing plants secrete sugars, organic acids, and other compounds that provide a good source for soil microorganisms. The area around plants is called the rhizosphere. This area contains the highest concentration of microorganisms in the soil. By keeping an actively growing crop in the soil, microorganisms can recycle nutrients to promote healthy soil.

Measuring Soil Health

- Changes in soil health happen over time. Therefore, measuring soil health is challenging. However, scientists can use tests to assess soil health.

- Soil organic matter. Soil organic matter increases the nutrient- and water-holding capacity of soil. Organic matter is an important indicator of soil health.

- Soil respiration. This test measures microbial activity in the soil. It is also a good predictor of plant-available nutrients from soil organic matter.

- Potentially mineralizable nitrogen. This test estimate the fraction of nitrogen in organic matter that may be converted to plant-available nitrogen. If soils have a high concentration of potentially mineralizable nitrogen, producers may be able to cut back on nitrogen fertilizer applications.

- Soil aggregation. Stable soil aggregates increase water infiltration into the soil and are good indicators of soil health.

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