**Objective**: To investigate the physical and chemical characteristics of different types of soils and apply that knowledge to develop a soil suitable for productive agricultural practices.

**Introduction:**

Soils are composed of three major constituents: sand, silt, and clay. The different components of a soil are referred to as fractions, namely, the sand, silt, clay, and organic fractions. Soil types have been characterized by field and laboratory tests which are based on certain common chemical and physical properties. In this lab activity, you will test many of the physical and chemical characteristics of several known soil types to gain an understanding of the differences between major soil types. Soil samples from burned and unburned areas at Quail Hollow Park will be compared to determine how fire affects soil properties.

**Part 1, Physical Characteristics of Soils:**

* ***Soil Texture Triangle Test***

The texture of a soil is based on the relative proportions of these constituents in a given soil. The different class names are shown in the soil texture triangle below. The colloidal portion (sub-microscopic particle size, large surface area) of soil.

1. Fill a tall, slender jar ¼ full of your soil sample.

2. Add water until the jar is ¾ full.

3. Cover the cylinder with film and shake hard for 15 minutes and until the soil is thoroughly suspended in the water. Place the cylinder on the lab station and leave it to settle overnight

4. When the soil has settled out, there should be 3 distinct layers. Measure the volume of each layer and the total volume of the sample.

5. Calculate the percentage of each component.

Amount of each component x 100 = % component

Total volume of soil

6. Identify the type of soil in your sample by using the soil texture triangle. To use the soil triangle, find the % sand first, % clay second, and % silt last. The point where these three percentages meet is the soil type.

|  |  |  |  |
| --- | --- | --- | --- |
| Soil Type | Layer Thickness | Soil % | Soil Type |
| Burned | Sand \_\_\_\_\_\_\_\_\_\_\_\_\_  Silt \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Clay \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Sand \_\_\_\_\_\_\_\_\_\_\_\_\_  Silt \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Clay \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |  |
| Unburned | Sand \_\_\_\_\_\_\_\_\_\_\_\_\_  Silt \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Clay \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Sand \_\_\_\_\_\_\_\_\_\_\_\_\_  Silt \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Clay \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |  |

* ***Soil texture by feel*** –

1. Take a handful of soil in the palm of your hand. Mist it with tap water from the spray bottle. Soak up any excess water by adding more soil a pinch at a time.
2. Squeeze the sample. Does it form a ball? If no, add more water. If no again, you have *sand.*
3. Once you have formed a ball the size of one or two large marbles, knead it until all aggregates are broken up. Then, make a ribbon by squeezing the dirt flat between your thumb and forefinger. At the same time, push upward with your thumb until it forms a ribbon. The ribbon should run past your forefinger and may be between 1 cm and 5 cm in length. Measure the ribbon and record its length in your data table.
   1. *Use the clay sample for practice. It should form a ribbon that is at least* 5 cm long *before it breaks. If you have trouble getting a* 5 cm *ribbon, make sure your ribbon is uniform in thickness. If you have a thick area of soil at the* end *of the ribbon, it will serve as a weight and cause the ribbon to break prematurely. Similar problems may occur if you make an area in the middle of the ribbon thinner than the rest. Practice with the clay until you can confidently make a ribbon;* then *use this technique* on *your soil sample.*
4. If the sample did not form a ribbon, you have *loamy sand.*
5. If the sample made a ribbon of less than 2.5 cm long and feels gritty to the touch, you have *sandy loam.*
6. If it feels smooth rather than gritty, you have *silt loam.*
7. If there is no gritty or smooth feeling, you have *loam.*
8. If the sample made a ribbon of 2.5 cm to 5.0 cm long and feels gritty to the touch, you have *sandy clay loam.*
9. If not gritty, but smooth, you have *silty clay loam.*
10. If there is no definite gritty or smooth feeling, *clay loam.*
11. If the sample made a ribbon of 5.0 cm long or more, and feels gritty to the touch, you have *sandy clay.*
12. If not gritty, but smooth, you have *silty clay.*
13. If there is no definite gritty or smooth feeling, *clay.*

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| --- | --- | --- |
| **Soil Type** | **Description** | **Ribbon Length** |
| Gravel |  |  |
| Course Sand |  |  |
| Fine Sand |  |  |
| Silt |  |  |
| Clay |  |  |
| Burned |  |  |
| Unburned |  |  |

* ***Porosity*** - Porosity is the percentage of open spaces or pores in a given volume of rock or sediment. Porosity determines the total amount of water a rock will hold, and varies from one material to another. The greater the volume of pore spaces a rock or sediment contains, the higher its porosity, and the more water it can hold.

1. Place cap on soil tube.
2. Fill 100 mL graduated cylinder with water.
3. Fill the soil tube w/ water from the graduated cylinder and **record** the volume of water required to fill up to **2 cm from top**: (= total volume of tube.) \_\_\_\_\_\_\_\_\_\_\_ mL = volume of water
4. Empty the tube & dry it before going on.
5. Fill the tube with soil sample #1 (you will repeat steps for each sample)
6. Tap to gently settle and compact the particles. Add more of particle type to bring level **2 centimeters** from the top.
7. Fill graduated cylinder with water, noting volume.
8. Now slowly pour water into soil tube until the sample is fully saturated and the water level just reaches the top of the soil level.
9. Check the new water level in the graduated cylinder, and **record** volume of water added to the tube in the data table.
10. Calculate porosity of each of the three samples tested. Porosity is calculated by dividing the **volume** **of the pore space by the total volume of the sample**.
11. Empty your wet/used soil samples in the marked containers ( not the container that you got the dry soil from).

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| --- | --- | --- | --- | --- |
| **Soil Type** | **Volume of Water in Grad. Cyl. (mL)** | **Water added to Soil Tube (mL)** | **Volume of Soil (mL)** | **Porosity** |
| Gravel |  |  |  |  |
| Course Sand |  |  |  |  |
| Fine Sand |  |  |  |  |
| Silt |  |  |  |  |
| Clay |  |  |  |  |
| Burned |  |  |  |  |
| Unburned |  |  |  |  |

* ***Permeability*** - The permeability of a rock or sediment refers to its ability to transmit groundwater freely. The rate at which a material transmits water depends not only on its total porosity, but also on the size of the passageways between its openings. To be considered permeable, the open spaces in a rock must be connected. The size and sorting of the particles composing the rock or sediment will affect its permeability.

1. Fasten screening over one end of soil tube with rubber band.
2. Fill tube with sample #1 (you will repeat for each soil sample) up to one inch from the top.
3. Tap gently to settle/compact sample.
4. Fill graduated cylinder with water to 50 mL mark.
5. While holding soil tube over a plastic cup, pour 50 mL of water into soil tube. Time & record how long it takes for all water to drain through tube.
6. When water has completed draining, measure amount in graduated cylinder. Record volume in data table.
7. Calculate percentage of water retained by the soil particle type by **subtracting amount of water drained into the cup from the 50mL amount originally added**. **Divide this difference by the original 50mL** value to find the decimal amount and then multiply by 100 to arrive at the percentage.
8. Calculate the rate of drainage for each soil particle type by dividing the amount of water drained into the cup by the amount of time it took the water to drain.
9. Return “used” soil samples to marked containers.

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| --- | --- | --- | --- | --- |
| **Soil Type** | **Time of Drainage (sec.)** | **Water Drained from Soil Tube (mL)** | **Original Water Volume (mL)** | **Permeability** |
| Gravel |  |  |  |  |
| Course Sand |  |  |  |  |
| Fine Sand |  |  |  |  |
| Silt |  |  |  |  |
| Clay |  |  |  |  |
| Burned |  |  |  |  |
| Unburned |  |  |  |  |

* ***Water holding capacity*** - The water-holding capacity refers to the amount of water a soil is able to retain. This can be very important in agriculture as it refers to how much moisture can be available for plants to access. Water holding capacity of soil is mainly dependent upon two things: how much humus is in the soil, and the size of the particles. Although some soils can absorb their own weight or more in water, ideally the water content should only be 60-80% of the soils capacity. If soils contain less than 60% of their capacity for water, there is not enough water for the cellular needs of many organisms. If soils contain more than 80% of their capacity for water, there is too little oxygen available for the growth and activity of many microorganisms.

1. Place the filter paper on the end of the soil tube with a rubber band.
2. Slightly moisten the filter paper on the end of the can and determine its mass.
3. Place soil sample in the can and reweigh it.
4. Set the soil tube (filter paper down) in water, so that the lower half is immersed. Leave it for 14-16 hours (or overnight). After this time, remove from the water, transferring to rack where it can drain for approximately 30 minutes. Wipe surface of soil tube, blot once (5 sec) and determine the mass.
5. Determine the percent water holding capacity by dividing the **weight gained by water absorption in soil** by the **weight of dried soil**. Multiply the quotient by 100.

% water-holding capacity = mass gained by water absorption in soil x 100

mass of oven-dried soil

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| --- | --- | --- | --- |
| **Soil Type** | **Mass of Soil with Water (g)** | **Original Soil Mass (g)** | **Water Holding Capacity (%)** |
| Gravel |  |  |  |
| Course Sand |  |  |  |
| Fine Sand |  |  |  |
| Silt |  |  |  |
| Clay |  |  |  |
| Burned |  |  |  |
| Unburned |  |  |  |

**Part 2, Chemical Characteristics of Soils:**

* ***pH*** - A pH measurement of soil is a measure of acidity that is present in the soil solution. The pH measurement is a simple means by which the production potential of a soil can be evaluated. For example, soils in which the pH is extremely low, have correspondingly low calcium and magnesium levels with high levels of exchangeable acidity. At low pH levels, metal cations such as aluminum and manganese are much more soluble and can reach levels which are toxic to plants. These toxic components can be eliminated entirely by application of limestone to raise the pH. In addition to the reduction in the solubility of toxic metals, increased pH levels also enhance microbial activity within the soil. Hence, the key to good crop production is to maintain the pH within the range where plants and microbiological activity within the soil can function at their optimum level. For most soils this requires a pH between pH 6.0 and 6.5. Soil pH levels higher than 6.5 can create problems with certain micronutrients (manganese in particular).
* ***Soil nutrients (N, P, and K)*** - The major essential nutrient elements supplied through the soil are Nitrogen (N), phosphorous (P), and potassium (K). Nutrients absorbed from the soil by plants are supplied by decomposition of rock, decomposition of organic matter, deposition by flood waters, application of commercial fertilizers, and the use of animal or plant manures.

**Nitrogen** is the most abundant element in the atmosphere (about 80%), but the gaseous form cannot be absorbed by plants. However, a relatively large group of plants, the legumes, have root nodules that contain Rhizobium bacteria which convert gaseous nitrogen into a form usable by plants (nitrogen fixation). Nitrogen promotes succulence in forage crops and leafy vegetables. It stimulates above-ground growth, hastens crop maturity, and is very influential in fruit sizing.

**Phosphorous** is necessary for the hardy growth of the plant and activity of the cells. It encourages root development, and by hastening the maturity of the plant, it increases the ratio of grain to straw, as well as the total yield. It plays an important part in increasing the palatability of plants and stimulates the formation of fats, convertible starches, and healthy seed. By stimulating rapid cell development in the plant, phosphorous naturally increases the resistance to disease.

**Potassium** is not a component of the structural makeup of plants, but it plays a vital role in the physiological and biochemical functions of plants. The exact function of potassium in plants is not clearly understood, but many beneficial factors implicating the involvement and necessity of potassium in plant nutrition have been demonstrated. Some of these factors are: it enhances disease resistance by strengthening stalks and stems, activates various enzyme systems within plants, contrinbutes to a thicker cuticle which guards against disease and water loss, controls the turgor pressure within plants to prevent wilting, enhances fruit size, flavor, texture, and development, and is involved in the production of amino acids, chorophyll formation, starch formation, and sugar transport from leaves to roots.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Soil Type** | **N** | **P** | **K** | **pH** |
| Gravel |  |  |  |  |
| Course Sand |  |  |  |  |
| Fine Sand |  |  |  |  |
| Silt |  |  |  |  |
| Clay |  |  |  |  |
| Burned |  |  |  |  |
| Unburned |  |  |  |  |

**Part 3, Designing Optimal Soil for Agriculture:**

Productive agriculture is greatly dependent upon the type of soil present on the land. The type of crops grown in a region may be limited by the type of soil present. Additionally, farmers often enrich their soils to increase plant productivity. Using your knowledge of the physical and chemical characteristics of soils, develop a soil that would be suitable for productive agricultural productive. Maintain clear and detailed records of how you created your “ideal” soil, gather data to provide evidence of the characteristics of your soil, and argue from this evidence as to why your soil is appropriate for successful agricultural practices.

*Designer Soil Composition*:

|  |  |  |
| --- | --- | --- |
| **Type of Soil** | **% of Soil Composition** | **Rationale** |
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|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

*Evidence of Characteristics of Soil*:

Perform a soil texture triangle test as well as a minimum of three tests to provide evidence regarding the suitability of the soil. Record the name of each test, data collected, and a statement describing the importance of the test and its outcome.

Soil Triangle Test

|  |  |  |
| --- | --- | --- |
| Thickness | Percent | Soil Type |
| Sand \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Clay \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Silt \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Sand \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Clay \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Silt \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |  |

Test 1 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Data table:

Importance of test:

How do the results of the test affect agricultural practices:

Test 2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Data table:

Importance of test:

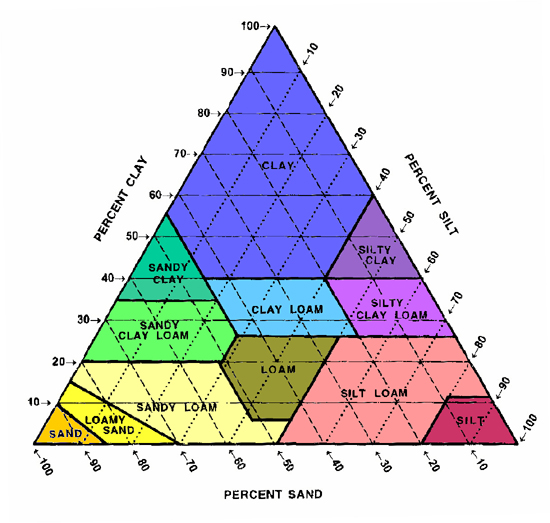
How do the results of the test affect agricultural practices:

Test 3 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Data table:

Importance of test:

How do the results of the test affect agricultural practices:



**Conclusion**:

*Explain why the soil you designed is ideal for optimizing agricultural productivity. Refer to the evidence you gathered from your soil tests to support your argument and relate it to how it will serve to create suitable soils for agriculture.*