

Forensic Science

SOILS: Environmental Forensics

Curriculum for
Investigative Science

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Forensic Science Units
ENVIRONMENTAL FORENSICS: SOILS
Teachers Guide and Lesson Plans

I. Rationale

When pondering the subject of "Forensic Science", most individuals will call to mind events they have read about in the newspaper or seen on television shows like C.S. I. Las Vegas. Criminal cases involving evidence such as blood spatter, fingerprints, or ballistics come to mind readily as these are the events most frequently discussed in the media. These are the topics of high profile cases. However, it is important to remember that the "sciences" we are speaking of when using the term "forensic science" refer to many more scientific disciplines than those mentioned above. In truth, any science can be translated into a forensic science merely by applying its' analytical findings to the law written by a governing body. And it is therefore the goal of this curriculum module to introduce students to science through the forensic investigative techniques with which students might not be as familiar.

With these lessons, students will investigate the fundamental scientific concepts behind the forensic evaluation of soils. Students will identify characteristics in a given set of data, construct qualitative observations, and place information into a classification system. Students will gain experience using tools and instruments to collect evidence and practice safety procedures in all activities. In addition, students will utilize the scientific method to formulate hypotheses, interpret data, and arrive at conclusions using their laboratory results.

We have designed these lesson plans to be easily modified as needed by the teacher. It is our goal that teachers can choose to present all of the material in one comprehensive package or just pull out specific activities/topics to use as mini-lessons. In all of the activities, additional suggestions and time-saving tips are included at the end.

II. Objectives

A. Cognitive objectives:

Upon completion of this module, the student will be able to:

- understand terminology associated with soil and vocabulary associated with the investigative examinations thereof.
- understand the processes by which soils are produced.
- understand the various processes used to classify soils.
- make observations of different soil samples under an ultraviolet source
- compare and contrast soil appearances in visible vs. UV light
- be introduced to the Munsell Color System developed by Albert H. Munsell in the first decade of the twentieth century
- understand how the Munsell system works based on the idea that colors are a combination of three color dimensions – hue, value, and chroma
- be able to state several reasons why it is important to know the exact color of a soil
- analyze the density range of components of soil
- discuss the observations made about components of soil and their relative densities
- discuss the validity of their hypothesis
- recognize density as the determining factor in settling rate of components of soil
- identify components of soil by reading a chart
- classify soils based on %T vs. time graphs
- recognize reactivity as an indicator of carbonates or metals in the soil
- classify soils based on the vigorousness of the reaction
- compare techniques to determine validity
- learn about soil forming factors and soil structure
- analyze soil structure
- be able to determine the consistency of a soil using the friability test
- discuss the varying factors that play a role in determining the consistency of a soil
- learn the definition of soil texture
- be able to identify the texture of a soil by
 - analyzing the relative sizes of soil particles
 - analyzing the way a soil sample “feels” and “behaves” through a series of diagnostic queries

B. Skills and Performance objectives:

Upon completion of this module, the student will be able to:

- Exhibit the proper safety procedures when working with pH buffer solutions and spectrophotometers.
- Demonstrate the correct procedure for using a pH meter, a spectrophotometer, color charts, and soil sieves.
- Report data in an appropriate manner.
- become proficient at using the Munsell system to identify colors of soil
- make observations about components of soil as related to density
- make observations about the settling rate of the components of soil
- hypothesize what relative densities different types of soil components will have
- calculate percentages of components of soil
- make observations about % transmittance for different soil samples

- make observations about the reactivity of soil in acids
- make qualitative observations about pH of soils
- make quantitative observations about pH of soils
- use technology to make quantitative observations
- participate in a field investigation of soil

III. Soil Drying Technique

Each lab group will need 4-6 samples of soil taken from different areas. It works best to dry a larger amount of soil before starting any of the labs. You will need to collect approximately 2.5 kilograms of each type/location of soil to have enough for all laboratory experiments. You will need approximately $\frac{1}{2}$ to $\frac{2}{3}$ of a gallon-sized baggie of each type of soil. For example, one gallon bag of sand is equal to approximately 5.7 kilograms but sand is denser than other types of soil.

The dried soil can be used for any of the labs that are included in this module. Some labs require the soil to be dry while others require that it be moistened. It is better to have it all dried and ready to go so as not to have to stop in between labs and spend several hours drying samples. This may take a couple of days to get completely ready.

It is recommended that the soil be heated at **225°F** for at least **three hours**. It is very easy to make aluminum foil liners to put on top of cookie sheets under the soil. Because of the large amount of soil needed to accommodate all lab groups, it is a good idea to just heat one or two samples at a time, each on their own foil liners.

After each sample is dried, place them in gallon-sized baggies and label the location from which it was collected and the sample name you chose. You can even include the GPS coordinates if you would like. You could tell the students the two reference streets nearest the location of the collected sample and have the students look up the GPS coordinates on the internet.

Example: Sample A/ Indian Hills Road & South Douglas Blvd./35°17'25"N and 97°22'16"W

***NOTE: The above soil can be used for all of the soil activities in this module except for the “SOIL PROFILING: IT’S A DIRTY BUSINESS” activity. The soil for that lab must be obtained from different horizon layers in the soil profile.**

Environmental Forensic Science: Soils
SOIL INTRODUCTION—WHAT ARE THE DIRTY DETAILS?
Teacher's Guide

PRE-ACTIVITY 1

Take a few minutes to think about "soil". When you think about this, what does the concept of soil look like in your mind? Use the space below to jot down characteristics about soil. Try to think of as many features as you can.

List of Characteristics About Soil

The students might suggest things like:

- *it is dirt / dust*
- *it is the material that plants grow in*
- *it is brown or red or different colors*
- *it can stain fabrics*
- *it has nutrients in it*
- *micro-organisms live in the soil*
- *it contains rocks and other mineral debris*
- *different plants can grow in different soils*
- *it has different-sized materials*
- *it can be transported by water, wind, animals, humans*
- *it supports objects of small to great masses*
- *depending on the soil it can hold varying volumes of water*
- *it can become contaminated*
- *soil profiles in different regions can vary greatly*
- *it contains air*
- *soil is living / or non-living*
- *it contains organic matter*
- *is comprised of layers*
- *it has a distinct "earthy" smell*
- *has a texture*
- *the soils have different pH*

My Definition of "Soil"— After you feel you have made a good comprehensive list, write a descriptive definition for soil in the indicated space below.

The students will have varying responses to this question.

After the students have made their lists and written their definitions, ask them to work with a partner in discussing their ideas. After a few minutes of discussion, have them agree on one definition of soil they will share in a few moments with the class in a discussion.

Small Group Definition of “Soil” – Discuss with a partner your initial list of features about soil, and then discuss your definitions of soil. Talk it over, see what things are similar and different, and then come to a consensus on one good definition of soil.

The students will have varying responses to this question.

Lead a discussion with the class. Ask the students to share the characteristics they brainstormed on their initial lists. Tell the students that throughout the class discussion, they may add to their lists any ideas they did not include originally. You can write these out on an overhead, or on the board as a working list.

Next, ask for volunteers to share their definitions for soil. Write these down as well so the students can see the commonalities and differences between definitions of different groups. After some discussion, ask them which one they feel to be the best overall definition. Also, ask them what characteristics they feel need to be included in the definition, and which ones are not as important.

Ask them if they feel that there is one specific universal scientific definition for soil. After hearing their thoughts, explain to the students that there are actually many varying definitions for “soil”. It depends on who is defining it – the government, University Professors, gardeners, geophysicists, etc.

*Show the students a copy of the following **Definitions of “SOIL” sheet**. Have students volunteer to read the definitions. After they have all been read, ask the students to write down any words from the definitions they do not know the meaning of or do not recognize.*

“Definitions of Soil” information sheet— After reading all of the definitions, write down any individual words you don't know the definition of, or words you do not recognize in the space provided below.

Students may say that words such as “organic”, “unconsolidated”, “differentiated”, “constituents”, “macro-organisms”, “superficial”, “decaying”, and “mantle”, and possibly others are new to them. You can choose to go over these now, or discuss them as they come up in the activities in the module.

Ask the students what they think – do they feel that any of the definitions are better than the rest? If so, why do they feel they are better? Do any of the definitions appear somewhat weak, in that they do not include very much information? Take a class vote to see which definition the students feel is the best one.

PRE-ACTIVITY 2

Look at the following words: SOIL, DIRT, GRIME, DUST, and MUD. In a few short sentences, write out what you believe to be the difference between these words.

After the students have had a few moments to think about and write out their definitions for the words, have a brief discussion taking volunteers to share answers. Then go over the module definitions with them. They can modify their answers as needed.

Soil – we established this approximate definition above

Grime – dust that has been mixed with body grease or other greases or oils and partly dried

Mud – dirt or soil that has been moistened in the form of a paste

Dust – accumulation of debris in a state of pulverization;

- **inorganic dust** – debris from things such as pulverized rock fragments and metal dust
- **organic dust** – debris from things such as fecal matter, vegetable matter, animal matter, microorganisms, debris from manufactured products and occupational processes; example: textile industry

* It is important to note that because of the microscopic size of most of the particles, dust can become airborne. It may also settle out onto any surface.

Dirt – constituents of soil, dust, and other debris –organic, mineral, animal hair, human skin cells, etc. Because these materials are no longer located in/at their point of origination, they are now undesirable and fall into the broad category of “dirt”

DEFINITIONS OF “SOIL”:

- the upper layer of earth that may be dug or plowed and in which plants grow (**Merriam-Webster Online Dictionary**)
- the superficial unconsolidated and usually weathered part of the mantle of a planet and especially of the earth (**Merriam-Webster Online Dictionary**)
- The naturally occurring, unconsolidated or loose covering of broken rock particles and decaying organic matter on the surface of the Earth, capable of supporting life. (en.wikipedia.org/wiki/Soil)
- The unconsolidated mineral or organic matter on the surface of the earth that has been subjected to and shows effects of genetic and environmental factors of: climate (including water and temperature effects), and macro- and microorganisms, conditioned by relief, acting on parent material over a period of time. A product-soil differs from the material from which it is derived in many physical, chemical, biological, and morphological properties and characteristics. (en.wiktionary.org/wiki/soil)
- A dynamic natural body composed of mineral and organic materials and living forms in which plants grow. (www.asca-consultants.org/what_glossary.html)
- The top layer of the earth's surface, consisting of rock and mineral particles mixed with organic matter. (www.gardensimply.com)
- Soil is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment. (**Soil Taxonomy 2nd Edition**)
- Generally the upper layers of earth in which plants grow. A good soil consists of sand, organic matter, clay particles, air pockets and water molecules. The dominate material determines the soil composition and designation, such as sandy, silt, bentonite, clay or loam. www.csu.org/environment/xeriscape/resources/page3862.html)
- The upper weathering part of the earth's crust, commonly but not always differentiated into horizons, of mineral and organic constituents (cf. Joffe 1949, pp. 39-41). According to this definition soil does not include living organisms. (www.nzetc.org/tm/scholarly/tei-Bio16Tuaf02-t1-body-d2.html)
- The superficial weathered layers of the Earth's crust and any intermixed organic material. (www.lasgrwc.org/LandscapeEthic/GlossaryNov17.doc)

Environmental Forensic Science: Soils
SOIL INTRODUCTION—WHAT ARE THE DIRTY DETAILS?
Student Discovery Activity

PRE-ACTIVITY 1

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List of Characteristics About Soil

My Definition of “soil”— After you feel you have made a good comprehensive list, write a descriptive definition for soil in the indicated space below.

Small Group Definition of “soil”—Discuss with a partner your initial list of features about soil, and then discuss your definitions of soil. Talk it over, see what things are similar and different, and then come to a consensus on one good definition of soil.

“Definitions of Soil” information sheet—After reading all of the definitions, write down any individual words you don't know the definition of, or words you do not recognize in the space provided below.

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Look at the following words: SOIL, DIRT, GRIME, DUST, and MUD. In a few short sentences, write out what you believe to be the difference between these words.

DEFINITIONS OF “SOIL”:

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- The superficial unconsolidated and usually weathered part of the mantle of a planet and especially of the earth (**Merriam-Webster Online Dictionary**)
- The naturally occurring, unconsolidated or loose covering of broken rock particles and decaying organic matter on the surface of the Earth, capable of supporting life. (en.wikipedia.org/wiki/Soil)
- The unconsolidated mineral or organic matter on the surface of the earth that has been subjected to and shows effects of genetic and environmental factors of: climate (including water and temperature effects), and macro- and microorganisms, conditioned by relief, acting on parent material over a period of time. A product-soil differs from the material from which it is derived in many physical, chemical, biological, and morphological properties and characteristics. (en.wiktionary.org/wiki/soil)
- A dynamic natural body composed of mineral and organic materials and living forms in which plants grow. (www.asca-consultants.org/what_glossary.html)
- The top layer of the earth's surface, consisting of rock and mineral particles mixed with organic matter. (www.gardensimply.com)
- Soil is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment. (**Soil Taxonomy 2nd Edition**)

- Generally the upper layers of earth in which plants grow. A good soil consists of sand, organic matter, clay particles, air pockets and water molecules. The dominate material determines the soil composition and designation, such as sandy, silt, bentonite, clay or loam. (www.csu.org/environment/xeriscape/resources/page3862.html)
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Environmental Forensic Science: Soils
SOIL TRIVIA - DO YOU HAVE THE “DIRT” ON SOIL?
Teacher’s Guide and Key

Read each of the following statements and answer the question to the best of your ability – some of these may be tricky so watch out☐:

- The top one inch of the forest floor contains an average of 800 living creatures for each square foot. True or False?
 - **False – there are over 1400 living organisms per square foot**
- Read the statement: Soil can be found in the following colors – black, yellow, red, white, gray, purple, and brown. Which of the colors listed do you believe IS NOT really considered to be a classification color for soil?
 - **Purple**
- In one tablespoon of forest soil, there are at least two billion bacteria and millions of fungi, protozoa and algae. True or False?
 - **True**
- Fertile topsoil is 10% air. True or False?
 - **False – it is actually ≈ 50%**
- More than 4 billion tons of topsoil is lost each year through erosion by wind and water. True or False?
 - **True**
- The weight of bacteria across one acre of land is equivalent to the weight of one or two cows. True or False?
 - **True**
- Over 42 centuries ago, ancient China used soil maps to determine how much to tax its citizens. True or False?
 - **True**
- Can you name the three size divisions for particles of soil?
 - **Sand, silt, and clay**
- Which type of common medicine is obtained almost wholly from microorganisms in the soil?
 - **Antibiotics**
- Which is the greater number: the number of microorganisms in a tablespoon of soil or the number of people on Earth?
 - **Microbes in a tablespoon of soil**
- The shrinking and swelling of soil can cause damage to buildings, roads and other structures. Do you think that the cost to repair this damage is MORE or LESS than the cost to repair damage as a result of hurricanes, tornadoes and floods?
 - **More to repair soil damage!**
- Which has a higher number of distinct species: a shovelful of garden soil or the entire Amazon Rain Forest (above ground)?
 - **Amazon Rain Forest**
- Soil is a living system. True or False?
 - **True**
- Soil is 33% silicon, 7% aluminum, 4% iron, 2% carbon, and 49% what other element?
 - **Oxygen**
- Each year, over 15 tons of dry soil per acre passes through which soil organism?
 - **Earthworms**

- It takes 1500 gallons of water provided by soil to grow one bushel (35.25 liters) of corn and 4000 gallons to grow one bushel of wheat. True or False?
 - **False – it takes 4000 gallons to grow a bushel of corn and 11,000 gallons to grow a bushel of wheat**
- Soil is made up of mineral material resulting from physical and chemical weathering of rocks, and organic matter. True or False
 - **True**
- What does “organic” mean?
 - **Having been recently living; capable of decay, a product of decay, or is composed of organic compounds; organic compounds are those that are composed primarily of carbon and secondarily of other nonmetallic elements.**
- It takes 500 years to form 1 inch (or 2.54 cm) of soil. True or False?
 - **True**
- Soil is a non-renewable natural resource. True or False?
 - **True – This answer may seem strange to us, as we know that over time rocks continue to weather physically and chemically, and that organisms continue to decay. We also know that critters such as earthworms continue to digest the organic matter in the soil deriving their nutrition from microorganisms such as bacteria and fungi on the dead and decaying matter. In addition, even many more microorganisms are present in their feces or casts than in the organic matter that they consume. As organic matter passes through their intestines, it is broken down and infused with microbes. Increased microbial activity facilitates the cycling of nutrients from organic matter and their conversion into forms that can be readily taken up by plants. Worms also aerate the soil, creating new and bigger pores which allows more water and air to get into the soil, and roots to grow deeper. SO.....if all of these things are continual processes over time, why then is soil considered a non-renewable resource? The answer lies in the actual time frame itself. Soil is a renewable resource, but not in a human lifetime. So if humans do not take care of the soil and it then becomes infertile, we will be in big trouble!**
- The US has over 36,000 hazardous waste sites present in our soils. True or False?
 - **True**
- Aeolian soils are soils that are transported to a new location by what force?
 - **Wind – Aeolian are named after the Greek god Eolus, who was the keeper of the winds.**
- How many trees do you think the average person uses a year in paper, wood and other products from trees?
 - **Seven trees**
- This is cool! In a 100-year period, a water molecule spends 98 years in the ocean, 20 months as ice, about two weeks in lakes and rivers, and less than a week in the atmosphere. That leaves approximately three months time in the ground.

Environmental Forensic Science: Soils
SOIL TRIVIA - DO YOU HAVE THE "DIRT" ON SOIL?
Student Activity Sheet

Read each of the following statements and answer the question to the best of your ability – some of these may be tricky so watch out☐:

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- Which type of common medicine is obtained almost wholly from microorganisms in the soil?
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- Which has a higher number of distinct species: a shovelful of garden soil or the entire Amazon Rain Forest (above ground)?
- Soil is a living system. True or False?
- Soil is 33% silicon, 7% aluminum, 4% iron, 2% carbon, and 49% what other element?
- Each year, over 15 tons of dry soil per acre passes through which soil organism?
- It takes 1500 gallons of water provided by soil to grow one bushel (35.25 liters) of corn and 4000 gallons to grow one bushel of wheat. True or False?
- Soil is made up mineral material resulting from physical and chemical weathering of rocks, and organic matter. True or False
- What does “organic” mean?
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- The US has over 36,000 hazardous waste sites present in our soils. True or False?
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- How many trees do you think the average person uses a year in paper, wood and other products from trees?
- **This is cool! In a 100-year period, a water molecule spends 98 years in the ocean, 20 months as ice, about two weeks in lakes and rivers, and less than a week in the atmosphere. That leaves approximately three months time in the ground.**

Environmental Forensic Science: Soils
SOIL COLORS—HUE KNEW SOIL COULD BE SO MANY COLORS?
Teacher's Guide

Purpose/Objectives: Students will...

- be introduced to the Munsell Color System developed by Albert H. Munsell in the first decade of the twentieth century
- understand how the Munsell system works based on the idea that colors are a combination of three color dimensions – hue, value, and chroma
- become proficient at using the Munsell system to identify colors of soil
- be able to state several reasons why it is important to know the exact color of a soil

Information

There are two good choices available for guides for the identification of soil colors. The best choice is the **MUNSELL Color Chart**. It has over 300 color chips for more specific identification. It costs around \$115.00 per binder. The other choice, the **GLOBE Soil Color Book**, is more economical at around \$45.00, but it contains only approximately 200 color chips for reference. For practical purposes of the middle school or high school classroom, the Globe Soil Color Book should work just fine.

How To Use The Color Chart:

The color identification is made up of three parts: the hue, the value and the chroma. Take **5YR 4/2** as an example.

5YR is the hue. The hue is the “color” and can range from 1 to 10 in number and can have 10 combinations of letters. The letters stand for one of the five main color hues (**Red**, **Yellow**, **Green**, **Blue**, and **Purple**) or one of the five in-between hues (**Yellow-Red**, **Green-Yellow**, **Blue-Green**, **Purple-Blue**, and **Red-Purple**). Therefore, **5YR** stands for midway through the Yellow-Red band of hues. **5Y** stands for midway though only the yellow band of hues. The Globe color chart puts hues together in sequential sections of pages. So, for the example of **5YR**, the chart would group all **5YR** hues on pages 18-21.

4 is the value of the color and this is the lightness of the color with 0 being black and 10 being white. The Globe color chart indicates change in value by going up or down a page.

2 is the chroma of the color and this is the “purity” of the color. Lower numbers mean less purity (like pastels) and higher numbers mean more purity. Different colors have different ranges of chroma because of the sensitivity differences that the human eye has for various colors. For example, take the colors yellow and purple. The human eye is more sensitive to variations within the color yellow than it is within the color purple. This means there will be more chroma numbers for yellows on the color chart. There will not be as many for purple. The Globe color chart indicates change in chroma by turning the page (moving horizontally) within a section.

Explain to the students how to match the soil colors to the chart. With an appropriate amount of sunlight over their shoulder, have them “eyeball” the soil color first, and then turn to a section of the book they think the color of their soil mostly resembles. Then they will take a small amount of soil, about 5-10 grams, and actually lay it on the pages of the book, moving it across the bands of colors until they find a really good match. When the students

are finished with the sample, have them discard it in the trash and wipe the soil residue off the laminated book.

Lastly, before starting the lab, explain to the students why it is important to establish the color of a soil. Color of soil can indicate:

- various processes acting upon, or within a soil such as biological, physical or chemical processes
- value of a soil in terms of fertility (nutrients and water)
- value of a soil in terms of integrity (for building purposes)
- presence of pollutants /degree of pollution (forensics)
- depth /layer (horizon) from which soil sample was collected
- location/region in a city, country, continent
- texture of the soil
- degree of drainage
- climate
- the amount of organic matter present

Following the lab, you might want to ask the students to look at their soil color books and see if they notice any pattern related to the numbering systems for hue, value, and chroma. See the following website for more in-depth information on this topic.

www.applepainter.com/Chap01/index.php

ACTIVITY: What color is your soil sample?

Materials: (per group)

- electronic balance
- 4-6 previously dried labeled soil samples in stock gallon-sized bags
- Munsell Color Chart or Globe Soil Color Book
- weigh paper or notebook paper cut into 4-6 equal squares (depending on the number of samples being tested)
- scissors
- plastic spoon

PROCEDURE:

1. Look at the Data Table on the back of this page. Record the names of the samples you are being given by your teacher.
2. Record also the general location from which the soil samples were taken. The GPS coordinates can be added now or at a later time if desired. Lastly, observe your soil samples for a few minutes. Come up with at least 5 descriptors you can use to describe your soils and record them in the space provided. At this time, the first three columns of the Data Table should be complete.
3. Take a piece of notebook paper and cut it into 4-6 equal-sized squares. Label each piece of paper with the names of the soil Samples (A, B, C, etc.)
4. Using the correct piece of paper that corresponds to the first sample, obtain 5-10 grams of the sample from your teacher. Take the first sample back to your lab table.

5. Using your color chart or soil color book, follow the instructions given by your teacher on how to use the Color Chart to locate the correct color. When you have located the correct color, record the code corresponding to this color in the space provided in the data table. Your code should look something like this:

10YR 6/3

where the 10YR is the “hue”, the 6 is the “value” and the 3 is the “chroma”.

6. Repeat these steps for each of the samples provided by your teacher.

Sample Name	Sample Location	Soil Appearance	Color Chart Code

Analysis:

- 1) What was the most specific description you used to describe one of your soil samples?

Answers will vary

- 2) Was it easy or difficult to find exact matches for your soil colors? If difficult, what is the reason for this?

Answers will vary

- 3) Rate your understanding of **HUE, VALUE, AND CHROMA** on a scale of 1-10, with 1 being "I do not really understand it at all" and 10 being "Munsell is my name, color is my game!"

1 2 3 4 5 6 7 8 9 10

Answers will vary

Environmental Forensic Science: Soils

SOIL COLORS—HUE KNEW SOIL COULD BE SO MANY COLORS?

Student Discovery Activity

Who invented the Color Chart system we will use today in the lab activity?

Albert H. Munsell (1858-1918) was an American art student at the Boston Normal Art School in the late 19th century. While studying there, he realized that there was no system at that time that fully defined the aspects of color. Through a lot of research and experimental procedures, Munsell sought to “bring clarity to color communication by establishing an orderly system for accurately identifying every perceptible color.”

www.coloracademy.co.uk/ColorAcademy%202006/subjects/munsell/munsell.htm

How To Use The Color Chart:

The color identification is made up of three parts: the hue, the value and the chroma. Take **5YR 4/2** as an example.

5YR is the hue. The hue is the “color” and can range from 1 to 10 in number and can have 10 combinations of letters. The letters stand for one of the five main color hues (**R**ed, **Y**ellow, **G**reen, **B**lue, and **P**urple) or one of the five in-between hues (**Y**ellow-**R**ed, **G**reen-**Y**ellow, **B**lue-**G**reen, **P**urple-**B**lue, and **R**ed-**P**urple). Therefore, **5YR** stands for midway through the Yellow-Red band of hues. **5Y** stands for midway though only the yellow band of hues. The Globe color chart puts hues together in sequential sections of pages. So, for the example of **5YR** chart would group all **5YR** hues on pages 18-21.

4 is the value of the color and this is the lightness of the color with 0 being black and 10 being white. The Globe color chart indicates change in value by going up or down a page.

2 is the chroma of the color and this is the “purity” of the color. Lower numbers mean less purity (like pastels) and higher numbers mean more purity. Different colors have different ranges of chroma because of the sensitivity differences that the human eye has for various colors. For example, take the colors yellow and purple. The human eye is more sensitive to variations within the color yellow than it is within the color purple. This means there will be more chroma numbers for yellows on the color chart. There will not be as many for purple. The Globe color chart indicates change in chroma by turning the page (moving horizontally) within a section.

When you are ready to start the activity in which you will match the soil colors to the chart, have an appropriate amount of sunlight over your shoulder and “eyeball” the soil color first, and then turn to a section of the book you think the color of your soil mostly resembles. Then you will take a small amount of soil, about 5-10 grams, and actually lay it on the pages of the book, moving it across the bands of colors until you find a really good match. When the your lab group is finished with the sample, discard it in the trash and wipe the soil residue off the laminated book.

Pre-lab questions: Why do you think it is important to establish the color of a soil? What types of things can we know if we know the color of a soil? As you and your classmates come up with ideas, fill them in below in the space provided.

ACTIVITY: What color is your soil sample?

Materials: (per group)

- electronic balance
- 4-6 previously dried labeled soil samples in stock gallon-sized bags
- Munsell Color Chart or Globe Soil Color Book
- weigh paper or notebook paper cut into 4-6 equal squares (depending on the number of samples being tested)
- scissors
- plastic spoon

PROCEDURE:

1. Look at the Data Table on the back of this page. Record the names of the samples you are being given by your teacher.
2. Record also the general location from which the soil samples were taken. The GPS coordinates can be added now or at a later time if desired. Lastly, observe your soil samples for a few minutes. Come up with at least 5 descriptors you can use to describe your soils and record them in the space provided. At this time, the first three columns of the Data Table should be complete.
3. Take a piece of notebook paper and cut it into 4-6 equal-sized squares. Label each piece of paper with the names of the soil Samples (A, B, C, etc.)
4. Using the correct piece of paper that corresponds to the first sample, obtain 5-10 grams of the sample from your teacher. Take the first sample back to your lab table.
5. Using your color chart or soil color book, follow the instructions given by your teacher on how to use the Color Chart to locate the correct color. When you have located the correct color, record the code corresponding to this color in the space provided in the data table. Your code should look something like this:

10YR 6/3

where the 10YR is the “hue”, the 6 is the “value” and the 3 is the “chroma”

6. Repeat these steps for each of the samples provided by your teacher.

Sample Name	Sample Location	Soil Appearance	Color Chart Code

Analysis:

- 1) What was the most specific description you used to describe one of your soil samples?

- 2) Was it easy or difficult to find exact matches for your soil colors? If difficult, what is the reason for this?

- 3) Rate your understanding of **HUE, VALUE, AND CHROMA** on a scale of 1-10, with 1 being "I do not really understand it at all" and 10 being "Munsell is my name, color is my game!"

1 2 3 4 5 6 7 8 9 10

Soil Characterization Protocol

Field Guide

Task

Identify, measure and record the horizons in a soil profile at a Soil Characterization Site.
Measure and record the physical and chemical properties that characterize each horizon.
Photograph the soil profile. Collect soil samples from each horizon.

What You Need

1. Spray mist bottle full of water
2. Acid bottle filled with distilled vinegar
3. Golf tees, nails or other marking device that can be pushed into a soil horizon
4. Soil Characterization Data Sheet
5. Trowel, shovel, or other digging device
6. Pencil or pen or other method of recording data
7. Soil color book
8. Paper towels
9. Marking pen
10. Meter stick or tape measure
11. Camera
12. Rolling pin, hammer, or other utensil for crushing peds and separating particles

In the Field

Identifying and Measuring Horizons

1. Make sure the sun shines on the profile if possible.
2. Use a trowel to scrape a few centimeters of soil off of the profile to expose a fresh soil face.
3. Determine whether the soil profile is moist, wet, or dry by lightly placing your hands on the Soil face. If the soil profile is dry, moisten it with the spray mist bottle.
4. Start at the top of the profile and observe the characteristics of the soil moving towards the bottom of the profile.
5. Feel carefully at the soil profile for distinguishing characteristics such as texture, shapes, roots, rocks, small dark nodules, worms, small animals, insects, and worm channels. These observations will help to define the horizons.
6. Working in a straight vertical line, place a marker (such as a golf tee or nail) at the top and bottom of each horizon to clearly identify it. Be sure there is a consensus from all of the students regarding the depths of the soil horizons.

7. Measure the top and bottom depth of each horizon beginning at the top (surface) of the profile. Start with the meter stick or tape measure at 0 cm at the top of the profile. Note the depths at which each horizon starts and ends.
8. Record the top and bottom depth of each horizon on the Soil Characterization Data Sheet.

Measuring Structure

1. Use a trowel or other digging device to remove a sample of soil from the horizon being studied.
2. Hold the sample gently in your hand and look closely at the soil to examine its structure.
3. Come to a consensus with other students in the group on the type of soil structure of the horizon. Possible choices of soil structure are:
 - **Granular**: Resembles cookie crumbs and is usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.
 - **Blocky**: Irregular blocks that are usually 1.5 - 5.0 cm in diameter.
 - **Prismatic**: Vertical columns of soil that might be a number of cm long. Usually found in lower horizons.
 - **Columnar**: Vertical columns of soil that have a white, rounded salt "cap" at the top. Found in soils of arid climates.
 - **Platy**: Thin, flat plates of soil that lie horizontally. Usually found in compacted soil.

IN certain cases, soil samples may have no structure. These would be classified as either:

- **Single Grained**: Soil is broken into individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.
- **Massive**: Soil has no visible structure, is hard to break apart and appears in very large clods.

4. Record the structure type on the Soil Characterization Data Sheet.

Measuring Main Color and Second Color

1. Take a ped from the horizon being studied and note whether it is moist, dry, or wet. If it is dry, moisten it slightly with water from your water bottle.
2. Break the ped and hold it next to the color chart.
3. Stand with the sun over your shoulder so that sunlight shines on the color chart and the soil sample you are examining.
4. Find the color on the color chart that most closely matches the color of the inside surface of the ped. Be sure that all students agree on the choice of color.
5. Record on the Soil Characterization Data Sheet the symbol of the color on the chart that most closely matches the soil color that covers the largest area of the ped (dominant or main color). Sometimes, a soil sample may have more than one color. Record a maximum of two colors if necessary, and indicate (1) the dominant (main) color, and (2) the sub-dominant (second) color.

Measuring Soil Consistence

1. Take a ped from the soil horizon being studied. If the soil is very dry, moisten the face of the profile by squirting water on it, and then remove a ped for determining consistence.
2. Holding the ped between your thumb and forefinger, gently squeeze it until it pops or falls apart.
3. Record one of the following categories of soil ped consistence on the Soil Characterization Data Sheet.
 - **Loose:** You have trouble picking out a single ped and the structure falls apart before you handle it. Note: Soils with single grained structure always have loose consistence .
 - **Friable:** The ped breaks with a small amount of pressure.
 - **Firm:** The ped breaks when you apply a good amount of pressure and the ped dents your fingers before it breaks.
 - **Extremely Firm:** The ped can't be crushed with your fingers (you need a hammer!)

Measuring Soil Texture

Step 1

- Place some soil from a horizon (about the size of a small egg) in your hand and use the spray mist bottle to moisten the soil. Let the water soak into the soil and then work it between your fingers until it is thoroughly moist. Once the soil is moist, try to form a ball.
- If the soil forms a ball, go on to Step 2. If the soil does not form a ball, call it a sand . Soil texture is complete. Record the texture onto the Soil Characterization Data Sheet.

Step 2

- Place the ball of soil between your thumb and index finger and gently push and squeeze it into a ribbon. If you can make a ribbon that is longer than 2.5 cm, go to Step 3. If the ribbon breaks apart before it reaches 2.5 cm, call it a loamy sand . Soil texture is complete. Record the texture onto the Soil Characterization Data Sheet.

Step 3

- If the soil:
 - Is very sticky
 - Hard to squeeze
 - Stains your hands
 - Has a shine when rubbed
 - Forms a long ribbon (5+ cm) without breaking,
- Call it a clay and go to Step 4.

- Otherwise, If the soil:
 - Is somewhat sticky
 - Is somewhat hard to squeeze
 - Forms a medium ribbon (between 2-5 cm)
- Call it a clay loam and go to Step 4.
- Otherwise, If the soil is:
 - Smooth
 - Easy to squeeze,
 - At most slightly sticky,
 - Forms a short ribbon (less than 2 cm)
- Call it a loam and go to Step 4.

Step 4

- Wet a small pinch of the soil in your palm and rub it with a forefinger. If the soil:
 - Feels very gritty every time you squeeze the soil, go to A.
 - Feels very smooth, with no gritty feeling, go to B.
 - Feels only a little gritty, go to C.

A. Add the word sandy to the initial classification.

- Soil texture is either:
 - sandy clay,
 - sandy clay loam, or
 - sandy loam
- Soil Texture is complete. Record the texture onto the Soil Characterization Data Sheet.

B. Add the word silt or silty to the initial classification.

- Soil texture is either:
 - silty clay,
 - silty clay loam, or
 - silt loam
- Soil Texture is complete. Record the texture onto the Soil Characterization Data Sheet.

C. Leave the original classification.

- Soil texture is either:
 - clay, clay loam, or loam
- Soil Texture is complete. Record the texture onto the Soil Characterization Data Sheet.

Measuring Rocks

1. Place your hands on the surface of the profile and feel for the presence of rocks along the face of the profile that you are studying. Observe and record if there are **none**, **few**, or **many** rocks or rock fragments in the horizon. A rock or rock fragment is defined as being larger than 2 mm in size.
2. Record your observation on the Soil Characterization Data Sheet.

Measuring Roots

1. Place your hands on the surface of the profile and feel for the presence of roots along the face of the profile that you are studying. Observe if there are **none**, **few**, or **many** roots in each horizon.
2. Record your observation on the Soil Characterization Data Sheet.

Photographing the Soil Profile

1. Place a tape measure or meter stick starting with 0cm from the top of the soil profile next to where the horizons have been marked.
2. With the sun at your back, photograph the soil profile so that the horizons and depths can be seen clearly.
3. Take another photograph of the landscape around the soil profile.
4. Submit photos to GLOBE following directions outlined in the How to Submit Photos and Maps section of the Implementation Guide.

Environmental Forensic Science: Soils
SOIL UV OBSERVATIONS—DO “U” V SEE WHAT I SEE?
Teacher’s Guide

Purpose/Objectives: Students will...

- make observations of different soil samples under an ultraviolet source
- compare and contrast appearances in visible vs. UV

PRE-ACTIVITY

It will be easier to classify the types of fluorescent materials if the observations are done with sieved soil. The students should look at each level of sieved soil individually. The room will need to be quite dark in order for observations to be made accurately.

ACTIVITY: Soil UV Observations

Materials

- dried soil samples
- UV source
- soil sieves

Introduction

The ultraviolet source gives off electromagnetic radiation in both the lower UV frequency range and the higher frequency range of the visible range (violet). When the lower UV waves hit some objects the electrons “jump” to a higher state and then fall back down to a lower state. Fluorescence occurs when the wave given off from the fall back down is in the visible range (and thus we can see it).

Procedure

1. Turn on the UV source.
2. Make the room to as dark as possible.
3. Separate particles that fluoresce under the UV Source.
4. Repeat for each sieved soil sample.
5. Record observations of colors and intensity.
6. Turn off the UV source and turn the room lights back on.
7. Record observations of the fluorescing particles without UV.

Sample Name	Sieve Size	Observations

Analysis

1) What colors of fluorescence did you see?

Possible colors are yellow-green, red, orange, blue and violet (purple).

2) Was there any correlation between size of particle and color? Give details.

Answers will vary.

3) Was there any correlation between color in normal light and color under the UV source? Give details.

Answers will vary.

4) If you had “specks” of color in the finely sieved soil, do you think that it is soil or something else? Why?

Answers will vary, but some “dust” particles fluoresce and the soil could be contaminated if it has been exposed in the inside air for very long.

Environmental Forensic Science: Soils
SOIL UV OBSERVATIONS—DO “U” V SEE WHAT I SEE?
Student Discovery Activity

Materials

- dried soil samples
- UV source
- soil sieves

Introduction

The ultraviolet source gives off electromagnetic radiation in both the lower UV frequency range and the higher frequency range of the visible range (violet). When the lower UV waves hit some objects the electrons “jump” to a higher state and then fall back down to a lower state. Fluorescence is when the wave given off from the fall back down is in the visible range (and thus we can see it).

Procedure

1. Turn on the UV source.
2. Make the room to as dark as possible.
3. Separate particles that fluoresce under the UV Source.
4. Repeat for each sieved soil sample.
5. Record observations of colors and intensity. Use the data table on the next page.
6. Turn off the UV source and turn the room lights back on.
7. Record observations of the fluorescing particles without UV.

Sample Name	Sieve Size	Observations

Analysis

1) What colors of fluorescence did you see?

2) Was there any correlation between size of particle and color? Give details.

3) Was there any correlation between color in normal light and color under the UV source? Give details.

4) If you had "specks" of color in the finely sieved soil, do you think that it is soil or something else? Why?

Environmental Forensic Science: Soils
SOIL DENSITY PROFILE—WHEN THE DIRT SETTLES
Teacher's Guide

Purpose/Objectives: Students will...

- make observations about components of soil as related to density
- analyze the density range of components of soil
- discuss the observations made about components of soil and their relative densities
- hypothesize what relative densities different types of soil components will have
- discuss the validity of their hypothesis

PRE-ACTIVITY

Make sure you have dried soil as described in soil drying technique. Make a density gradient tube by placing 8-10 mL of the following liquids in a graduated cylinder or centrifuge tube.

Corn Syrup, density ≈ 1.36 g/mL

Glycerin, density ≈ 1.173 g/mL

Water, density ≈ 1.0 g/mL

Corn Oil, density ≈ 0.894 g/mL

Rubbing Alcohol, density ≈ 0.786 g/mL

Put a small amount of well mixed soil (it is best to use a 30-45 mesh sieve to take out large particles) into the profile and let it sit for 12-24 hours

** Take care to not bump the profile or to put soil in too quickly as it can cause different layers to mix thus destroying the profile.*

The first part of this activity begins with the students in their lab groups looking over a list of the liquids in the density profile. A profile tube with no soil should be shown to the students.

ACTIVITY: When The Dirt Settles

Materials

- a profile tube with no soil in it
- profile tubes with soil that has had 12-24 hours to settle (brought out later)
- student activity sheets

Introduction

The tube given to your group has the following liquids with corresponding densities:

Corn Syrup ≈ 1.36 g/mL

Glycerin ≈ 1.173 g/mL

Water ≈ 1.0 g/mL

Corn Oil ≈ 0.894 g/mL

Rubbing Alcohol ≈ 0.786 g/mL

List the components of soil or things that might be found in the soil.

Answers will vary but things like rock, clay, silt, sand, organic matter, wood, roots, grass, etc.

Hypothesize/predict where each of the components you listed above will settle in the profile tube. Give a short explanation of your reasoning for each of your choices.

Answers will vary.

Record/sketch what layering occurred within the actual soil profile and compare to your hypotheses.

Usually organic matter like wood, grass, etc. is in the top two layers.

Write a short explanation for why the layering of the soil occurred in the manner you observed.

Answers will vary, but their argument should be about density and not size or weight independent of each other.

Environmental Forensic Science: Soils
SOIL DENSITY PROFILE—WHEN THE DIRT SETTLES
Student Discovery Activity

Materials

- a profile tube with no soil in it
- profile tubes with soil that has had 12-24 hours to settle (brought out later)
- student activity sheets

Introduction

The tube given to your group has the following liquids with corresponding densities:

Corn Syrup ≈ 1.36 g/mL

Glycerin ≈ 1.173 g/mL

Water ≈ 1.0 g/mL

Corn Oil ≈ 0.894 g/mL

Rubbing Alcohol ≈ 0.786 g/mL

List the components of soil or things that might be found in the soil.

Hypothesize/predict where each of the components you listed above will settle in the profile tube. Give a short explanation of your reasoning for each of your choices.

Record/sketch what layering occurred within the actual soil profile and compare to your hypotheses.

Write a short explanation for why the layering of the soil occurred in the manner you observed.

Environmental Forensic Science: Soils

SOIL SETTLING RATE—GETTING SPEC-IFIC!

Teacher's Guide

Purpose/Objectives: Students will...

- make observations about % transmittance for different soil samples
- classify soils based on %T vs. time graphs
- demonstrate proper usage of a standard spectrophotometer

PRE-ACTIVITY

The identifying factor with this lab is the SHAPE of the curve generated when you graph % Transmittance (%T) vs. time. The actual values of %T are not identifying. Sieving the soils to give uniform size may give better results. The spectrophotometers need to be on for 15 - 20 minutes before readings are taken. (Cool Idea: This can be done with an "unknown" taken from a suspect's shoe and then compared to the "known" found at a crime scene.)

ACTIVITY: Soil Settling Rate

Materials

- dried soil samples (0.5 grams each sample)
- Spectrophotometer (Spec-20 or other)
- Cuvettes
- Distilled Water

Introduction

The spectrophotometer measures the amount of light that passes through a sample in the cuvette. As the soil settles out of the water, more and more light should pass through. The percent transmittance (%T) will be measured as time passes. Soils made up of differing proportions of sand, silt, and clay will give different results when %T is graphed vs. time.

Procedure

1. Turn on Spectrophotometer and let it warm up for 15-20 minutes.
2. Set the wavelength to 450 nm.
3. Calibrate your spectrophotometer according to your instructor's directions.
4. Weigh 0.5 grams of each soil sample to be tested.
5. Pour the soil into the cuvette and fill to 3/4 full with distilled water.
6. Shake the cuvette vigorously for at least 1 minute.
7. Immediately place into the spectrophotometer and take a reading.
8. Continue taking readings at 30 second intervals for 10-12 minutes.
9. Graph the %T vs. time (all samples can be graphed on one graph).

Sample Name =>		Sample Name =>		Sample Name =>	
% T	Time	% T	Time	% T	Time
	0 Sec		0 Sec		0 Sec
	30 Sec		30 Sec		30 Sec
	60 Sec		60 Sec		60 Sec
	90 Sec		90 Sec		90 Sec
	120 Sec		120 Sec		120 Sec
	150 Sec		150 Sec		150 Sec
	180 Sec		180 Sec		180 Sec
	210 Sec		210 Sec		210 Sec
	240 Sec		240 Sec		240 Sec
	270 Sec		270 Sec		270 Sec
	300 Sec		300 Sec		300 Sec
	330 Sec		330 Sec		330 Sec
	360 Sec		360 Sec		360 Sec
	390 Sec		390 Sec		390 Sec
	420 Sec		420 Sec		420 Sec
	450 Sec		450 Sec		450 Sec
	480 Sec		480 Sec		480 Sec
	510 Sec		510 Sec		510 Sec
	540 Sec		540 Sec		540 Sec
	570 Sec		570 Sec		570 Sec
	600 Sec		600 Sec		600 Sec
	630 Sec		630 Sec		630 Sec
	700 Sec		700 Sec		700 Sec

Analysis

1) In what order do you think the components of soil (sand, silt, clay) settled?

Sand (within 30 seconds to two minute), Silt (takes 10 to 20 minutes), and then clay (some never settles out).

2) Which samples would you group together based on their SHAPE (not the actual values)?

Answers will vary.

3) Describe any patterns that you observed between soil samples and the graphs they produced.

Answers will vary.

Environmental Forensic Science: Soils
SOIL SETTLING RATE—GETTING SPEC-IFIC!
Student Discovery Activity

Materials

- dried soil samples (0.5 grams each sample)
- Spectrophotometer (Spec-20 or other)
- Cuvettes
- Distilled Water

Introduction

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Sample Name =>		Sample Name =>		Sample Name =>	
% T	Time	% T	Time	% T	Time
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	30 Sec		30 Sec		30 Sec
	60 Sec		60 Sec		60 Sec
	90 Sec		90 Sec		90 Sec
	120 Sec		120 Sec		120 Sec
	150 Sec		150 Sec		150 Sec
	180 Sec		180 Sec		180 Sec
	210 Sec		210 Sec		210 Sec
	240 Sec		240 Sec		240 Sec
	270 Sec		270 Sec		270 Sec
	300 Sec		300 Sec		300 Sec
	330 Sec		330 Sec		330 Sec
	360 Sec		360 Sec		360 Sec
	390 Sec		390 Sec		390 Sec
	420 Sec		420 Sec		420 Sec
	450 Sec		450 Sec		450 Sec
	480 Sec		480 Sec		480 Sec
	510 Sec		510 Sec		510 Sec
	540 Sec		540 Sec		540 Sec
	570 Sec		570 Sec		570 Sec
	600 Sec		600 Sec		600 Sec
	630 Sec		630 Sec		630 Sec
	700 Sec		700 Sec		700 Sec

Analysis

1) In what order do you think the components of soil (sand, silt, clay) settled?

2) Which samples would you group together based on their SHAPE (not the actual values)?

3) Describe any patterns that you observed between soil samples and the graphs they produced.

Environmental Forensic Science: Soils
SOIL COMPOSITION—SOIL...TAKE ME AWAY!
Teacher's Guide

Purpose/Objectives: Students will...

- make observations about the settling rate of the components of soil
- recognize density as the determining factor in settling rate of components of soil
- identify components of soil by reading a chart
- calculate percentages of components of soil

PRE-ACTIVITY

Make sure you have dried soil as described in soil drying technique. You will need to make enough 5% Calgon solution for each group to use 25 mL for each soil sample. To make the 5% Calgon (active ingredient sodium hexametaphosphate) solution put 5 mL of Calgon with 95 mL of distilled water.

ACTIVITY: Soil...Take me Away

Materials

- dried soil samples
- graduated 50 mL centrifuge tubes with lids
- stopwatch, clock, or timer

Introduction

The sodium hexametaphosphate in the Calgon acts as a dispersing agent for the peds of soil. It helps to break up the peds into their components (sand, silt, and clay). Labeling the tubes will be important since you will come back to them both a day later and a week later.

Procedure

1. Place soil into the centrifuge tube to the 25 mL mark.
2. Fill the tube up to the 50 mL mark with 5% Calgon solution.
3. Label the tube.
4. Shake the tube for 5 minutes.
5. Set the tube in a holder and start the timing device.
6. Record the level of the soil after 2 minutes.
7. Record the level of the soil after 20 minutes.
8. Record the level of the soil after 24 hours.
9. Record the level of the soil after 1 week.
10. For each sample
 - a. Record the level of the bottom layer (sand)
 - b. Record the level of middle layer (silt)
 - c. Record the level of top layer (clay)

Calculations

Total of the three layers (Total) - level of top of second layer = Clay

Clay \div Total \times 100 = % Clay

Total - Clay - level of top of first layer = Silt

Silt \div Total \times 100 = % Silt

Level of first layer = Sand

Sand \div Total \times 100 = % Sand

Identification

Use the chart below to identify the type of soil based on your percentages.

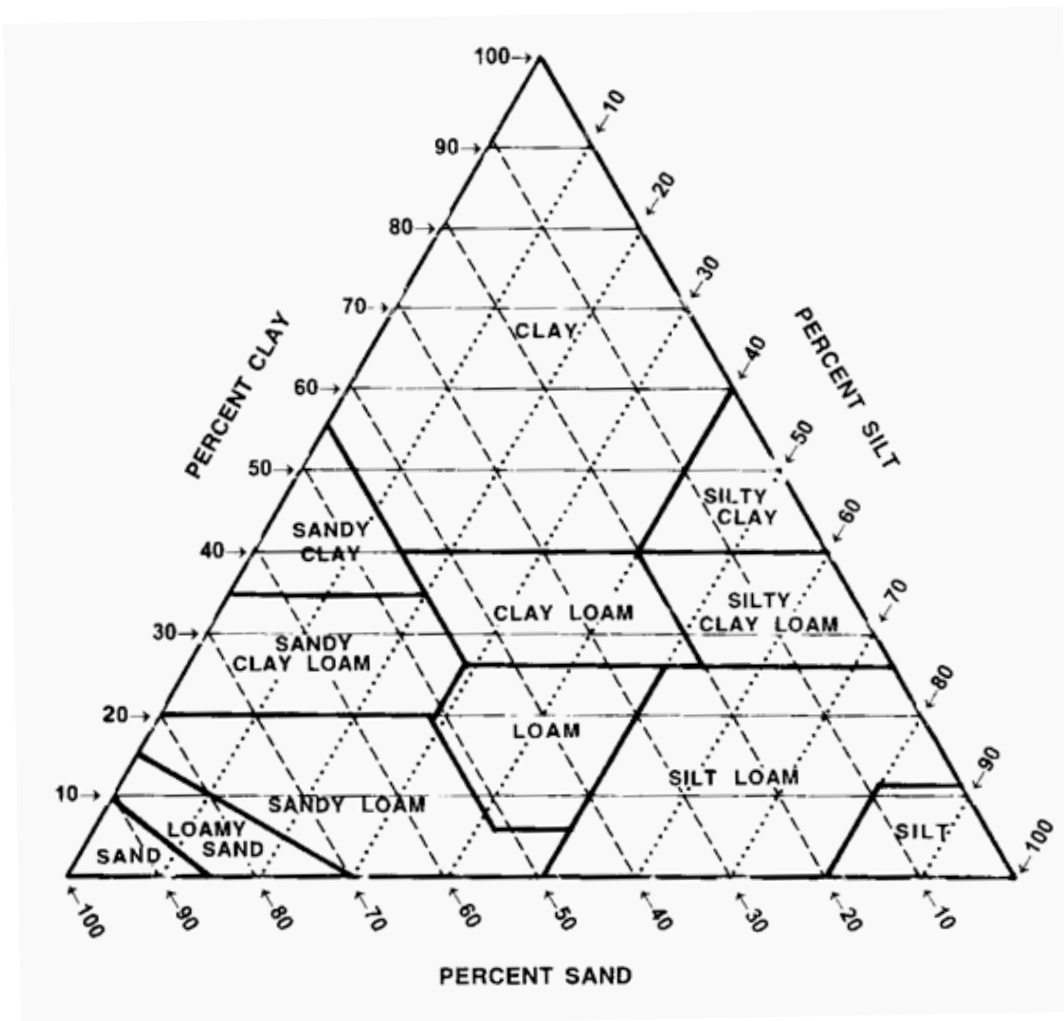


Image source: <http://www.ext.colostate.edu/mg/files/gardennotes/214-EstTexture.html>

Sample						
Total soil height (mL)						
Clay (mL)						
Silt (mL)						
Sand (mL)						
% Clay						
% Silt						
% Sand						
Type of Soil						

Analysis

1) Do all of your samples have three distinct layers? If not, identify the samples and determine which components (sand, silt, clay) are present.

Answers will vary.

2) Did the sand or silt levels change from the original levels after one week? If so, how did they change, would this change the percentages, and ultimately, the type of soil? Give a possible explanation for why they changed.

Most of the time the sand and sometimes the silt will settle more. The water will work its way out of the sand as particles slowly compact themselves and fill in "voids", thus displacing the water.

3) Discuss the variations of the soil types and if there is an correlation between location and type of soil.

Answers will vary.

Environmental Forensic Science: Soils
SOIL COMPOSITION—SOIL...TAKE ME AWAY!
Student Discovery Activity

Materials

- dried soil samples
- graduated 50 mL centrifuge tubes with lids
- stopwatch, clock, or timer

Introduction

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 - a. Record the level of the bottom layer (sand)
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 - c. Record the level of top layer (clay)

Calculations

Total of the three layers (Total) - level of top of second layer = Clay

Clay \div Total \times 100 = % Clay

Total - Clay - level of top of first layer = Silt

Silt \div Total \times 100 = % Silt

Level of first layer = Sand

Sand \div Total \times 100 = % Sand

Identification

Use the chart below to identify the type of soil based on your percentages.

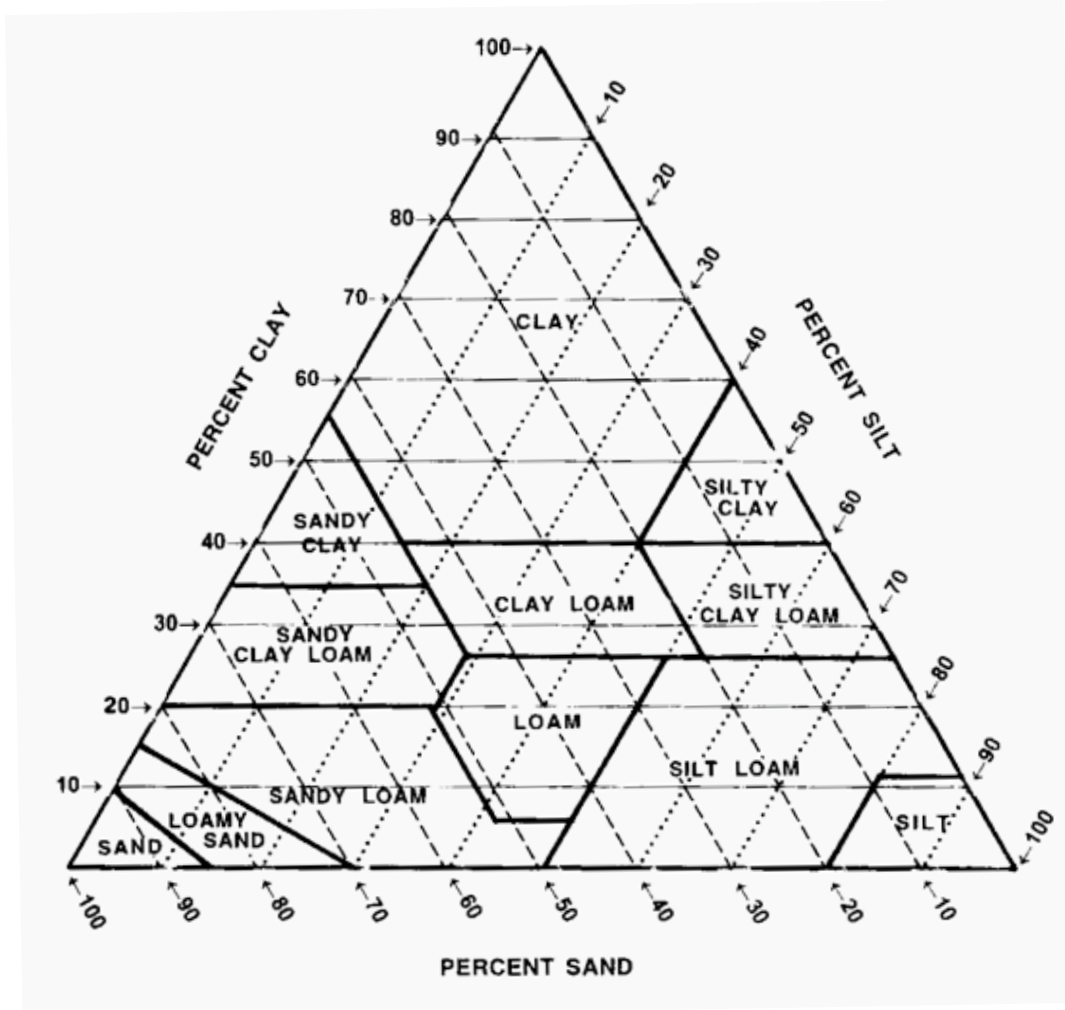


Image source: <http://www.ext.colostate.edu/mg/files/gardennotes/214-EstTexture.html>

Sample						
Total soil height (mL)						
Clay (mL)						
Silt (mL)						
Sand (mL)						
% Clay						
% Silt						
% Sand						
Type of Soil						

Analysis

1) Do all of your samples have three distinct layers? If not, identify the samples and determine which components (sand, silt, clay) are present.

2) Did the sand or silt levels change from the original levels after one week? If so, how did they change, would this change the percentages, and ultimately, the type of soil? Give a possible explanation for why they changed.

3) Discuss the variations of the soil types and if there is an correlation between location and type of soil.

Environmental Forensic Science: Soils
SOIL REACTION WITH ACID—EVERYTHING'S COMING UP BUBBLES!
Teacher's Guide

Purpose/Objectives: Students will...

- make observations about the reactivity of soil in acids
- recognize reactivity as an indicator of carbonates or metals in the soil
- classify soils based on the vigorousness of the reaction

PRE-ACTIVITY

Make sure you have dried soil as described in soil drying technique. You will need enough 1.0 Molar HCl for each group to put 10 drops on each sample. Vinegar can be used if students can not handle HCl, but the reactions are much weaker and harder to classify.

**Goggles should be worn throughout this lab.*

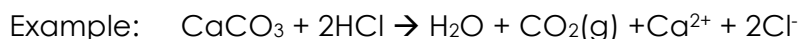
ACTIVITY: Acid-Soil Reaction

Materials

- dried soil samples
- goggles
- 1 M HCl in pipettes
- well plate

Introduction

When 1.0 Molar (dilute) HCl is placed on a soil it can effervesce (make bubbles) if carbonates are present. An example chemical equation for Calcium carbonate is given below.



Effervescence could also be an indicator of certain metallic elements (zinc, iron, magnesium etc.) But in most soil samples, it is an indicator of carbonates.

Procedure

1. Place a small amount (aspirin size) of each type of soil into a well on the well plate.
2. Pipette 10 drops of HCl onto a soil sample.
3. Record your observations in the table.
4. Label each reaction as either none, slight, moderate, significant, or vigorous.
5. Repeat for each sample.

Sample	Observations	Reaction Amount

Analysis

1) Which types of soils had the most reactivity, and what characteristics other than reactivity do they share?

Answers will vary.

2) Which types of soils had the least reactivity, and what characteristics other than reactivity do they share?

Answers will vary.

3) Based on your observations, what one general rule for acid-soil reaction would you include in a lab manual? (e.g. dark brown soils react more vigorously than red soils.)

Answers will vary.

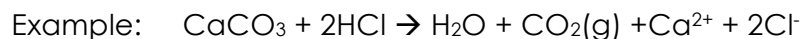
Environmental Forensic Science: Soils
SOIL REACTION WITH ACID—EVERYTHING'S COMING UP BUBBLES!
Student Discovery Activity

Materials

- dried soil samples
- goggles
- 1 M HCl in pipettes
- well plate

Introduction

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1) Which types of soils had the most reactivity, and what characteristics other than reactivity do they share?

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3) Based on your observations, what one general rule for acid-soil reaction would you include in a lab manual? (e.g. dark brown soils react more vigorously than red soils.)

Environmental Forensic Science: Soils

SOIL pH—pHUN WITH pH!

Teacher's Guide

Purpose/Objectives: Students will...

- make qualitative observations about pH of soils
- make quantitative observations about pH of soils
- use technology to make quantitative observations
- compare techniques to determine validity

PRE-ACTIVITY

Make sure you have enough dried soil as described in soil drying technique. You will need to calibrate any pH probes or meters that you will be using based on the instruction manual.

ACTIVITY: pHun with pH

Materials

- dried soil samples
- graduated 50 mL centrifuge tubes, graduated cylinders, or beakers
- de-ionized water
- stirring rod
- pH probe or meter
- pH paper (A/B Hydriion or Universal or red/blue litmus)
- stopwatch, clock, or timer
- study activity sheets

Introduction

The pH paper provides qualitative results while a pH probe or meter provides quantitative results. Basic solutions turn red litmus paper blue. Acidic solutions turn blue litmus paper red. Other types of pH papers will turn colors based on the specific pH value. You will be using a 1:1 ratio of soil to de-ionized water. You will be measuring the pH changes of the water because of the dissolved soil's ability to release H^+ ions into the water. De-ionized water does not always have a pH of 7. When the water is exposed to air, CO_2 easily dissolves in this type of water producing a slightly more acidic solution.

Procedure

1. Place 15 g of each soil sample into a container.
2. Add 15 mL of de-ionized water into the same container.
3. Use the stirring rod to stir the mixture for 1 minute.

4. Let the mixture stand for 1 minute.
5. Stir again for 1 minute.
6. Let the mixture stand for 3 minutes.
7. Dip one strip of pH paper into each sample. Use the guidelines for the specific pH paper to determine and record whether the solution is acidic or basic.
8. Use the pH probe/meter to determine and record the pH value for each sample.

Observations

Sample Name	pH Paper	pH Meter Values

Analysis

1) Did the pH paper results and the pH probe/meter values support each other? Cite evidence as an example.

Answers will vary.

2) What is an advantage of each technique? What is a disadvantage? Which technique would be better to use? Why would it be beneficial to use both techniques?

*pH paper yields immediate results. pH probe yields precise results.
pH paper yields only qualitative results not numerical measurements. pH probe has to be calibrated or could lead to false measurements.
Two of the same results will lead one to believe the results are accurate.
Using both techniques could be time consuming or if the results did not produce the same answer it could be misleading.
Answers will vary but most likely using the probe would be the better choice.*

3) Give reasons why some soils are more acidic or basic than others. Why would having different pH be advantageous?

*One can influence or change the pH of a given soil by adding various chemicals to the soil. The following contributes to acidic soils: fertilizers, urea, ammonium compounds, decomposing organic matter, sulphur, iron, aluminum. The following contributes to basic or less acidic soils: calcium carbonate and limestone.
Soils formed under rainy conditions tend to have a more acidic pH value while soils produced during dry conditions tend to have a more basic pH value.
Fertilizers and decomposing organic matter contributes to acidic soil. Soil fertility (i.e. the ability for a soil to support thriving plants) depends plenty on the elemental components and pH of the soil. Different plants prefer different pH profiles such as grasses—slightly acidic, 5.8 to 6.5, tomatoes—5.5, vegetables (general)—5.2 to 8.0, apples—5.0, hydrangea—pink flowers at 6.8 or higher, blue flowers at 6.0 or below.*

Environmental Forensic Science: Soils
SOIL pH—pHUN WITH pH!
Student Discovery Activity

Materials

- dried soil samples
- graduated 50 mL centrifuge tubes, graduated cylinders, or beakers
- de-ionized water
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Sample Name	pH Paper	pH Meter Values

Analysis

1) Did the pH paper results and the pH probe/meter values support each other? Cite evidence as an example.

2) What is an advantage of each technique? What is a disadvantage? Which technique would be better to use? Why would it be beneficial to use both techniques?

3) Give reasons why some soils are more acidic or basic than others. Why would having different pH be advantageous?

Environmental Forensic Science: Soils

SOIL PROFILING—IT'S A DIRTY BUSINESS!

Teacher's Guide

Purpose/Objectives: Students will...

- learn about soil forming factors and soil structure
- participate in a field investigation of soil
- analyze soil structure

Information

The following information is also included in the student version of the lab activity. You can read through this material with them to give them background information before they begin their lab activities.

Soils have many different properties that when combined together can affect the way a soil behaves in a given setting. Some of these properties include texture, structure, and presence or absence of roots and rocks. These properties can determine how well the soil retains and drains water, how well a soil can support the weight of a building, and what types of crops can be grown in the soils. **How does a soil get to be the way it is?**

There are five identifiable factors that work together in nature to create a unique soil profile made up of several different layers. These factors are **Parent Material, Climate, Topography, Biota, all working together over Time, the fifth factor.**

Parent Material refers to the underlying geological material in which soils, and the layers or "horizons" that comprise these layers, ultimately form. Soil parent material can be comprised of organic materials, minerals, or bedrock. They can also be formed as a result of deposits from water, wind, glaciers, volcanoes, or material moving down a slope. As children generally receive many genetic characteristics from their parents, soils typically hold on to the structural characteristics of their parent material.

Climate refers to weathering forces such as wind, rain, heat, ice, snow, and other environmental forces. These forces have the potential to break down parent material and affect how fast or slow the processes that form soil occur.

Topography – The location of a soil on a landscape can affect how the forces of climate impact it. For example, soils at the bottom of a hill will get more water than soils on a graded slope, and soils on slopes that directly face the sun will be drier than soils on slopes that do not.

Biota refers to organisms, plants and animals, living on or within the soil. This includes humans and microorganisms. Different organisms utilize different amounts of water and nutrients in the soil. Organisms have the ability to decompose waste materials on the soil's surface or within the soil, which adds organic matter, fortifying the soil. Small organisms aerate the soil by moving soil particles around within the soil profile. The type and amount of vegetation planted in the soil serves to prevent erosive forces, which increases soil sustainability.

Time- The above four factors all assert themselves over many, many years, often hundreds or thousands of years.

SOIL STRUCTURE

Soil structure is the shape that the soil takes based on its physical and chemical properties. Each individual unit of soil structure is called a **ped** (refers basically to how bits of soil “clump”). Soil peds are located within the different layers of soil called **horizons**. To see these horizons, you can do one of two things. You can purchase a foot long Soil Sampling Tube (Carolina Biological Supply) that you would push down into a slightly moistened soil. You would then pull out the tube and be able to see at least 2-3 layered soil horizons.

The other option is to go yourself to a location near to you in which an embankment has been cut away – possibly on the edge of a road or by a lake. (You could take your class with you, but as this might not be feasible, the next best option is to take a picture of the cut-away soil to take back to your classroom.)

In either case, you would also need to take enough samples from each horizon layer for each of your lab groups to do the **Measuring Structure Lab Activity**.

ACTIVITY: MEASURING SOIL STRUCTURE

Materials

- several garden trowels or other digging device
- soil sampling tube (optional – from Carolina Biological Supply)
- computer paper for drawing a picture of the soil profile
- colored pencils
- black sharpie marker
- enough quart-sized baggies to get needed samples for each horizon per group
- digital camera

The students will either follow Procedure I OR Procedure II, depending on the resource availability at each school.

Procedure I – Use this procedure if the teacher is **able** to take students out into the field to an actual location to observe and extract soil from multiple vertical horizons of a soil profile.

1. Locate an area in which the soil has been cut away vertically so that multiple layers or horizons of earth can be seen.
2. Take several digital pictures to take back with you to the classroom. These can be used in a power point for later reference.
3. On a clean sheet of computer paper, use colored pencils to draw a picture of the soil profile. Include all visible layers. Use detail when drawing your picture. To the best of your ability, depict the colors of the soil horizons, and also try to incorporate a sense of the texture of the soil. **Record written observations in the data table provided.**
4. Use a garden trowel or other digging device to extract a sample of soil from the **TOP** horizon. Hold the sample in your hand. Look closely at the soil to examine its structure. **Record initial observations in the data table.**
5. Use the **SOIL STRUCTURE DESCRIPTIONS** sheet included in the lab activity to come to a consensus with members of your group as to the type of soil structure of the **TOP** horizon. There are 7 basic descriptions for structure. **Record your answer in the data table.**

6. With the members of your group, decide on names for the layered horizons. Once you have collected a sample, place it in a baggie and label the baggie with a sharpie marker.
7. Repeat Steps 4, 5 and 6 for each individual horizon, working from the top down. **Be sure** to record your data in the data table.

Procedure II – Use this procedure if the teacher is **unable** to take students out into the field to an actual location to observe and extract soil from multiple vertical horizons of a soil profile. If this is the case, the teacher will have collected samples from the field for the students and will have a power point slide picture to use for demonstration purposes in the classroom.

1. Look at the picture of the soil profile on the power point slide.
2. On a clean sheet of computer paper, use colored pencils to draw a picture of the soil profile. Include all visible layers. Use detail when drawing your picture. To the best of your ability, depict the colors of the soil horizons, and also try to incorporate a sense of the texture of the soil. **Record written observations in the data table provided.**
3. From the teacher, obtain a sample of the first horizon of the soil profile, the **TOP** horizon. Hold the sample in your hand. Look closely at the soil to examine its structure. **Record initial observations in the data table.**
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Sample	Observations

Analysis

- 1) Which horizon(s) of your soil profile do you feel has the most organic material? Explain.

Answers will vary.

- 2) Explain "biota." What would happen if all of the biota on earth was decreased by a fourth?

Answers will vary.

- 3) What did you learn about soil today that you did not previously know?

Answers will vary.

Environmental Forensic Science: Soils

SOIL PROFILING—IT'S A DIRTY BUSINESS!

Student Discovery Activity

Information

Soils have many different properties that when combined together can affect the way a soil behaves in a given setting. Some of these properties include texture, structure, and presence or absence of roots and rocks. These properties can determine how well the soil retains and drains water, how well a soil can support the weight of a building, and what types of crops can be grown in the soils. **How does a soil get to be the way it is?**

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7. Repeat Steps 4, 5 and 6 for each individual horizon, working from the top down. **Be sure** to record your data in the data table.

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5. With the members of your group, decide on names for the layered horizons. Once you have collected a sample, place it in a baggie and label the baggie with a sharpie marker.
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Sample	Observations

Analysis

- 1) Which horizon(s) of your soil profile do you feel has the most organic material? Explain.
- 2) Explain "biota." What would happen if all of the biota on earth was decreased by a fourth?
- 3) What did you learn about soil today that you did not previously know?

Environmental Forensic Science: Soils

SOIL TEXTURES I—ARE YOU FEELIN' IT?

Teacher's Guide

Purpose/Objectives: Students will...

- be able to determine the consistency of a soil using the friability test
- discuss the varying factors that play a role in determining the consistency of a soil

Information

The consistency of a soil refers to how easy or hard it is for a soil ped to break apart when it is squeezed. The students will use the 4-6 samples of soil dried described in soil drying technique.

ACTIVITY 1: Measuring Soil Consistency

Materials

- 4-6 dried soil samples
- hammer

Procedure

1. Take a ped from the soil horizon/sample being studied.
2. Observe each sample of dried soil **without touching them**. Hypothesize whether you think they look like they are "loose", "moderately firm" or "very firm". **Record these answers in the data table.**
3. Holding it between your thumb and forefinger, gently squeeze the ped until it pops or falls apart. Use the following classification guide for determining the consistence.

Loose	You have trouble picking out a single ped (clump) and the structure falls apart before you handle it. [soils with "single-grained" structure (see soil profiling lab) always have loose consistence]
Friable	The ped breaks with a small amount of pressure.
Firm	The ped breaks when you apply a good amount of pressure and dents your fingers before it breaks.
Extremely Firm	The ped can't be crushed with your fingers (you need a hammer!)

4. Record the category of soil consistence in the data table.
5. Repeat this procedure for all of your dried soil samples.

ACTIVITY 2: Measuring Rocks

Materials

- 4-6 dried soil samples
- metric ruler

Procedure

1. Observe if there are **none**, **few**, or **many** rocks or fragments of rocks in the sample / horizon. A rock or rock fragment is defined as being larger than 2mm in size.
2. Record your observation in the data table.
3. Repeat this process for each of the samples provided.

ACTIVITY 3: Measuring Roots

Materials

- 4-6 dried soil samples
- metric ruler

Procedure

1. Observe if there are **none**, **few**, or **many** roots in each horizon.
2. Record your observation in the data table.
3. Repeat this process for each of the samples provided.

Sample	Hypothesis	Observations Consistency	Observations Rocks	Observations Roots

Analysis

- 1) Were you surprised about any of the consistencies of the soils after initially just observing them, and then performing the tests?

answers will vary

- 2) What factors could contribute to the differences in soil consistency?

water/moisture content, mineral content, organic matter content and soil texture

- 3) Make a statement about what you discovered when analyzing rock content of your soil samples.

students may say that they found rocks of varying colors, sizes, and concentrations in their soil samples/answers will vary

- 4) Make a statement about what you discovered when analyzing root content of your soil samples.

students may say that they found rocks of varying colors, sizes, and concentrations in their soil samples/answers will vary

Environmental Forensic Science: Soils
SOIL TEXTURES I—ARE YOU FEELIN' IT?
Student Discovery Activities

ACTIVITY 1: Measuring Soil Consistency

Materials

- 4-6 dried soil samples
- hammer

Procedure

1. Take a ped from the soil horizon/sample being studied.
2. Observe each sample of dried soil **without touching them**. Hypothesize whether you think they look like they are “loose”, “moderately firm” or “very firm”. **Record these answers in the data table.**
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Extremely Firm	The ped can't be crushed with your fingers (you need a hammer!)

4. Record the category of soil consistence in the data table.
5. Repeat this procedure for all of your dried soil samples.

ACTIVITY 2: Measuring Rocks

Materials

- 4-6 dried soil samples
- metric ruler

Procedure

1. Observe if there are **none**, **few**, or **many** rocks or fragments of rocks in the sample / horizon. A rock or rock fragment is defined as being larger than 2mm in size.
2. Record your observation in the data table.
3. Repeat this process for each of the samples provided.

ACTIVITY 3: Measuring Roots

Materials

- 4-6 dried soil samples
- metric ruler

Procedure

1. Observe if there are **none**, **few**, or **many** roots in each horizon.
2. Record your observation in the data table.
3. Repeat this process for each of the samples provided.

Sample	Hypothesis	Observations Consistency	Observations Rocks	Observations Roots

Analysis

- 1) Were you surprised about any of the consistencies of the soils after initially just observing them, and then performing the tests?

- 2) What factors could contribute to the differences in soil consistency?

- 3) Make a statement about what you discovered when analyzing rock content of your soil samples.

- 4) Make a statement about what you discovered when analyzing root content of your soil samples.

Environmental Forensic Science: Soils
SOIL TEXTURES II—WE’VE GOTTA HAND IT TO YOU!
Teacher’s Guide

Purpose/Objectives: Students will...

- learn the definition of soil texture
- be able to identify the texture of a soil by
 - analyzing the relative sizes of soil particles
 - analyzing the way a soil sample “feels” and “behaves” through a series of diagnostic queries

Information

The texture of a soil refers to the size of the particles that make up the soil, and the amount of each particle type in the soil. The terms sand silt and clay refer to relative size of the soil particles. Another way to think about it is the way the soil feels when wet or dry. **Sand**, the larger of the soil particles, feels gritty, while **silt** feels floury in texture and is moderate in size. **Clay** being the smallest in particle size feels very sticky.

The Relative Sizes of Sand, Silt and Clay

Very Coarse Sand 2.0 to 1.0 mm

Coarse Sand 1.0 to 0.5 mm

Medium Sand 0.5 to .25 mm

Fine Sand .25 to .10 mm

Very Fine Sand .10 to 0.05 mm

Silt 0.05 to 0.002 mm (medium fine)

Clay below 0.002 mm (very fine)

FYI - It takes 12,000 clay particles lined up side by side to make 1 inch!

What are some things we can do to get an idea about the texture of a soil? The students will be doing the following soil texture-by-feel analyses in their lab activity.

- **Feel Test** - How does the soil feel to you? Does it feel gritty, smooth or sticky?
- **Ball Squeeze Test** – How easily does the soil ball up? Does the soil remain in a ball? Will it even make a ball?
- **Ribbon Test** – Will the soil form a ribbon when pressed between the thumb and forefinger?

You will need to familiarize yourself with the Ribbon Test Procedures before having the students try it. It is not hard; there are just a few things to note about the procedure that will be helpful for you to be able to demonstrate or tell them.

It is a very good idea for you to go ahead and try the test out yourself ahead of time so will know exactly what the students will be experiencing.

THINGS TO NOTE:

- the amount of soil placed in the hand needs to be about 1/2 to 2/3 the size of a small boiled egg
- look at the picture on the flow chart; it shows what a “ribbon” of soil looks like
- when determining “ribbon breakage”, you will measure the amount that goes higher than the forefinger before breaking
- when determining if it is “equally gritty and smooth”- it tells you on the flowchart to “Moisten A Pinch Of the Soil in the Palm and Rub With Forefinger” – you need to make sure the kids **gently** rub their pointer across the surface of their palm

ACTIVITY: Soil Ribbon Test

Materials

- 4-6 dried soil samples
- water
- metric ruler
- paper towels
- trash can

Procedure

1. Obtain one of your soil samples. You will need enough soil to make a ball in your hand the half the size of a boiled egg.
2. Read the Soil Ribbon Test flowchart before beginning the lab. This is very important so you will understand what to do.
3. Follow the instructions with your soil sample.
4. Record your results in the data table.
5. Repeat the procedures with the remaining soil samples.

Sample	Texture

Analysis

1) Did you find the procedure to be simple or more difficult? Which elements of the procedure seemed to be difficult to understand or perform?

Answers will vary/students may say it was hard to determine degree of grittiness and/or smoothness

2) How did your results differ from what you expected?

Answers will vary

Environmental Forensic Science: Soils
SOIL TEXTURES II—WE'VE GOTTA HAND IT TO YOU!
Student Discovery Activity

Information

The texture of a soil refers to the size of the particles that make up the soil, and the amount of each particle type in the soil. The terms sand silt and clay refer to relative size of the soil particles. Another way to think about it is the way the soil feels when wet or dry. **Sand**, the larger of the soil particles, feels gritty, while **silt** feels floury in texture and is moderate in size. **Clay** being the smallest in particle size feels very sticky.

The Relative Sizes of Sand, Silt and Clay

Very Coarse Sand 2.0 to 1.0 mm

Coarse Sand 1.0 to 0.5 mm

Medium Sand 0.5 to .25 mm

Fine Sand .25 to .10 mm

Very Fine Sand .10 to 0.05 mm

Silt 0.05 to 0.002 mm (medium fine)

Clay below 0.002 mm (very fine)

FYI - It takes 12,000 clay particles lined up side by side to make 1 inch!

What are some things we can do to get an idea about the texture of a soil? The students will be doing the following soil texture-by-feel analyses in their lab activity.

- **Feel Test** - How does the soil feel to you? Does it feel gritty, smooth or sticky?
- **Ball Squeeze Test** – How easily does the soil ball up? Does the soil remain in a ball? Will it even make a ball?
- **Ribbon Test** – Will the soil form a ribbon when pressed between the thumb and forefinger?
- when determining if it is “equally gritty and smooth”- it tells you on the flowchart to “Moisten A Pinch Of the Soil in the Palm and Rub With Forefinger” – you need to make sure the kids **gently** rub their pointer across the surface of their palm

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Analysis

1) Did you find the procedure to be simple or more difficult? Which elements of the procedure seemed to be difficult to understand or perform?

2) How did your results differ from what you expected?