Carrie Taylor

# Investigating Soil: Qualitative Properties, Aeration, Percolation, Strength, pH, and Biodiversity with the Berlese Funnel

| | |
|---|---|
| **Grade Level** | Qualitative Properties and Biodiversity analyses are appropriate for all ages. Other activities are appropriate for middle school and older. |
| **Subject Areas** | Biology, Soil |
| **Skills** | observation, classification, comparison, identification, data analysis |
| **Duration** | Allow at least 30 minutes to set up the Burlese Funnel with the lamp on over the soil sample.<br>Depending on the number of measurements done and sites this activity could take one to several class periods. |
| **Setting** | 1. Anywhere outside: road, off-trail, near water. This activity is much more effective with a comparison of samples from at least two different sites (i.e. forest floor and road).<br>2. The Berlese Funnel biodiversity study is best in the classroom with samples. |
| **Vocabulary** | pH<br>soil texture – clay, silt, and sand<br>soil structure |
| **Standards Addressed** | National Science Education Standards K-4: Content A – Science as Inquiry, Content B – Physical Science (properties of objects and materials), Content C – Life Science (organisms and environments), Content D – Earth and Space Science (properties of earth materials), Content F –Science in Personal and Social Perspectives (changes in the environment)<br>National Science Education Standards 5-8: Content A – Science as Inquiry, Content C – Life Science (structure and function, organisms, ecosystems, decomposers, diversity, adaptations), Content D – Earth and Space Science (soil), Content F –Science in Personal and Social Perspectives (environmental degradation)<br>National Science Education Standards 9-12: Content A – Science as Inquiry, Content C – Life Science (biological evolution, the interdependence of organisms), Content F –Science in Personal and Social Perspectives (natural resources, environmental quality) |
| **Objectives** | **Students will:**<br>● Gain an understanding of the components of soil.<br>● Perform qualitative and quantitative measurements.<br>● Observe the differences between soil in different habitats (if sampling from different habitats). |

● Observe how management effects soil (if sampling from natural and disturbed soil).

**Materials**

For the field portion of this activity, you will need for each group:
● soil auguer
● container for weighing soil
● 100 mL measuring device
● 1 cup measuring device
● Penetrometer
● data sheet
● scale
● soup can with both ends removed
● soil pH kit
● soil pH comparison charts
● hand lenses
● shovel

For the Burlese Funnel part of this activity, best done in the classsroom, you will need:
● large plastic funnel
● circular piece of window screen to fit in the funnel
● glass jar
● petri dishes
● 100 W or greater lamp
● hand lenses

**Background**

Soil is one of the foundations for life on Earth. The physical and biological components of soil affect the health of the ecosystem it supports. Soil is a mixture of mineral ingredients of different particle size -rock, sand, silt, and clay, plus organic ingredients (living organisms and decomposing organic – plant or animal - matter), water, and air spaces. The spaces in the soil are critical to plant growth, since they are where roots grow, where moisture (moisture facilitates the transfer of nutrients to the roots), air and nutrients are stored, and contain oxygen and other gases for microbial activity. The ratio of these components in relationship to other environmental factors helps determine how well soils can sustain plant and animal life (nutrient and water holding capacities), act as a storage of water, withstand erosion, act as a filter for impurities, cycle nutrients, and support man-made structures.

In addition to the physical properties, soils also have different chemical properties. Soil pH is a measure of the concentration of the hydrogen ions in soil water. The pH is influenced by the "parent" rock (e.g., granite weathers to an acidic soil while limestone weathers to a basic soil) and type of vegetation present (e.g., pine needles acidify soil). The pH of the soil affects the nutrients available to root systems.

Most plants grow best in soil with a relatively even amount of sand, silt and clay. Sand particles are larger than the other types, so large pores form between sand grains. An adequate amount of sand is needed so that the soil drains well. Also sandy soil is easy for plant roots to penetrate. Clay particles are very small, and tiny "voids" that store water form between clay particles. Some clay is needed in the soil to hold water for plants. Organic matter is also needed because it holds moisture and provides nutrients to plants. Plants also grow best in soil where the pH is around neutral (7.0) or slightly higher. In this pH range, plant nutrients are most available, while if the pH is too high or low, many nutrients can leach out of the soil.

Organisms in the soil play integral roles in an ecosystem. They decompose organic compounds, sequester nitrogen and other nutrients, fix nitrogen from the atmosphere, enhance porosity, and are food for other organisms.
The physical and biological factors of soil differ between environments and are also influenced by land-use practices. Observations and data from the soil can be taken and compared to determine the health of the ecosystem/sampling site.

**Procedure**

1. Set up the Burlese Funnel with the soil sample at least 30 minutes before students examine the soil organisms.
2. Work as a group to gather data on the soil in your site. You may want to assign a (couple) student(s) to each task and/or split the group into two to sample from different sampling sites.
   a. Describe the location, mentioning the plants, and woody debris in the site.
   b. Take an auger or shovel of soil and describe the physical properties. Be sure to note color, smell, the presence of organic material, and texture.
   c. Calculate the air space in a 100 mL sample of soil
      i. Measure 100 mL of soil into a container (be careful not to compact the soil sample)
      ii. Weigh the container and 100 mL of soil
      iii. Fill the container with water to the top of the soil
      iv. Weigh the container, soil, and water
      v. The difference between the two weights is the weight of the water
      vi. Convert this measurement to the volume of air in the soil sample (1 gram of water displaces 1 mL of air)
   d. Measure the rate of soil percolation by
      i. Place the end of the soup can 1" into the ground
      ii. Pour 1 cup (240mL) of water into the can

iii. Record how long it takes for the water to completely disappear

e. Measure the soil strength using the Penetrometer.
f. Measure the soil pH using a soil pH kit.
g. Observe, identify, and count soil organisms using hand lenses and/or in a Berlese Funnel. To make a Berlese Funnel:
    i. Place a plastic funnel in a glass jar.
    ii. Place a piece of window screen (mesh small enough so that most soil particles won't fall through but small soil arthropods will) in the bottom of the funnel.
    iii. Place a soil sample about one inch thick on top of the screen. Make sure to include organic material on the top of the soil.
    iv. Place the lamp directly over the top of the funnel, as close to the soil sample as is possible. It is best if the lamp creates some heat.
    v. Allow the funnel to sit with the light on for at least thirty minutes, possibly longer. The invertebrates in the soil will move downward, away from the heat and light, pass through the screen, and fall into the jar below.
    vi. Put the contents of the jar in a petri dish and examine with a hand lens.

3. Facilitate a discussion based on the results and conclusions that may be drawn. Some valuable questions are listed below.
4. Facilitate a short summary of the physical and biological components of soil and importance of soil (see background).

**Assessment**

1. What observations did you make in surveying the soil?
2. What were the similarities and differences between the two soil sample sites? Why?
3. Now that you know the structure of soil, what are some functions of soil?

**Extension**

Measurements can be made in different ecosystems to compare soils in different environments. Other comparisons such as the plant community or animal activity could also be made. Measurements made in different management type such as on a dirt road versus in a forest can be used to discuss the effects of land management. (Percolation would differ due to compaction on the road.)

These measurements could be part of a student-led research project where they are engaged in each step of the scientific process: 1) Determining a scientific question with objectives and purpose, 2) Forming a testable hypothesis, 3) Creating a study with experimental design and methods, 4) Collecting data, 5) Analyzing data, and 6) Making and discussing conclusions from data.

Students could bury organic objects (e.g., stick, apple, celery) in different soils and measure decomposition over time and make comparisons between soil type.

The functions of soil can be investigated.

**Resources**

Soil air space and percolation tests have been modified from Project Learning Tree.

*The Soil Food Web,* USDA and *Soil Physical Properties: Importance to Long-Term Forest Productivity,* Childs, Shade, Miles, Shepard, Froehlich can be found in the Soil section of the Background Information binder.

*Soil Ecology,* Ken Killham: source of soil pH charts

Soil habitat diagram

Soil texture by feel flow chart

Soil texture classes chart

Additional soil activities can be found at http://www.wtamu.edu/~crobinson/DrDirt.htm

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## Soil Investigation Data Sheet

**Surveyor:** **Date:**

**Location:** **Time:**

**Describe Location: (near road, near water, off-trail, north slope…)**

______________________________________________________________

**Describe plants and woody debris cover:**______________________________

______________________________________________________________

### Physical Properties
**Describe the soil:**

**Color:** ________________________________

**Smell:** ________________________________

**Organic Ingredients:** ________________________________

**Texture (see table below):** ________________________________

**Common Soil Textures of Mineral Ingredients:**

| Particle Size | Feel | Nutrient Holding Capacity | Air Space | Water Availability |
|---|---|---|---|---|
| Sand 2.0-0.05 mm | Gritty | Low | Many Large | Low |
| Silt 0.05-0.002 mm | Smooth | Medium | Many Small | Good |
| Clay <0.002 mm | Sticky | High | Few Tiny | Slow movement of water |

### Air Space

| | |
|---|---|
| **A) Weight of container + 100 mL of soil:** | |
| **B) Weight of container + water to the top of the soil:** | |
| **B) – A) Weight of water added to the container:** | |
| **Volume of air in this soil sample:** | |

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**(1 gram of water displaces 1 mL of air)** |____________|

**Soil Percolation**

**Measure the time it takes for 1 cup (240 mL) of water to completely disappear.**

**______________________________________________AVERAGE:____________**

**Soil Strength**

**Penetrometer Reading: _____________________________AVERAGE:__________**

**Soil pH**

**Soil Reaction Reading: ______________________________AVERAGE:_________**

**Soil Organisms**

**(One-celled bacteria, algae, fungi, protozoa, nematodes, microarthropods, earthworms, insects, small vertebrates, plants)**

| Name/Description of Organism | # Counted |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |

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# Soil pH Comparison Charts

***The pH of the soil affects the nutrients available to roots.***

## Soil pH

| 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|

**← Decreasing P availability**
**← Increasing Al and Mn toxicity**

**Decreasing P availability →**
**Decreasing Mn availability →**

**P = Phosphorus, Al = Aluminum, Mn = Manganese**

## Approximate pH tolerance of the major groups of soil microbes

| Soil microbe | pH | Tolerance |
|---|---|---|
| | 14 | |
| Some actinomycetes | 10 | Can tolerate increasing alkalinity |
| Most soil bacteria | 7 | |
| Most soil fungi | 5 | |
| Chemoautotrophic S-oxidizing bacteria | 1 | Can tolerate increasing acidity |

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Diagram of the soil habitat:

| | | |
|---|---|---|
| May 1[st] | Overview, future research<br>Wardle, Chapter 8, p. 295-307 | Discussion |
| May 3[rd] | Take home final distributed. | |
| Final Exam Friday, May 10[th] at 12 p.m. | | |

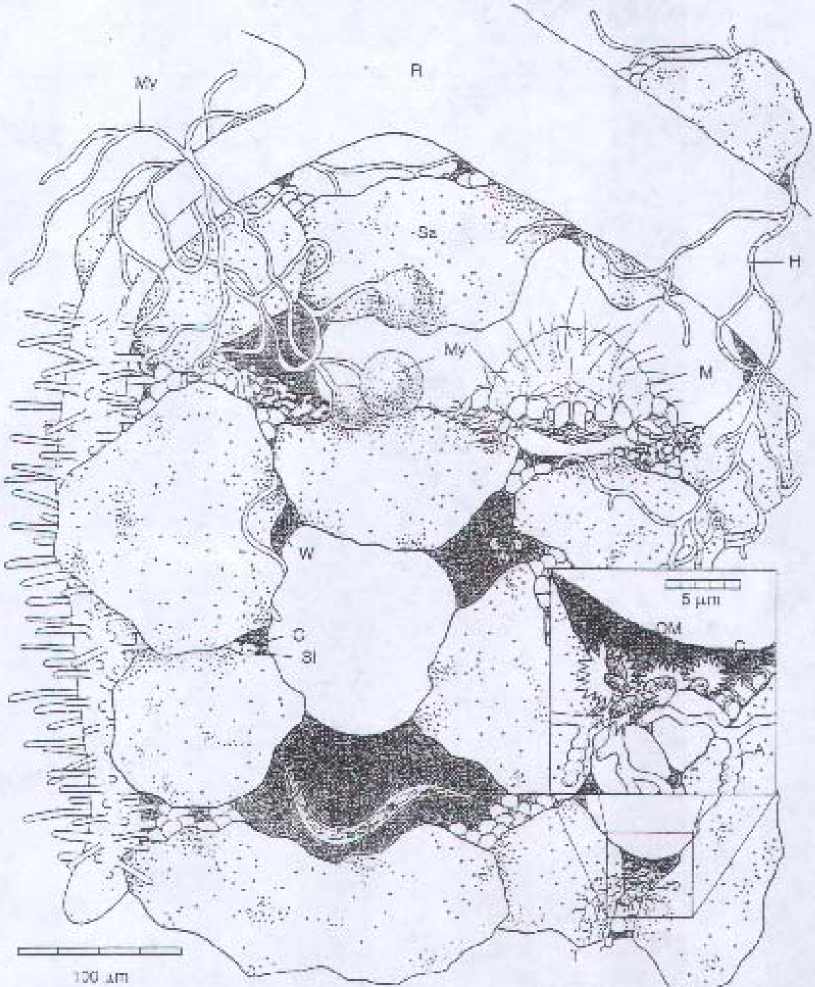


**Figure 1–2** A soil habitat containing mineral soil particles (sand-Sa, silt-Si, and clay-C), organic matter (OM), water (W), plant root with root hairs (R), and soil organisms (bacteria-B, actinomycetes-A, mycorrhizal spores and hyphae-My, hyphae of a saprophytic fungus-H, a nematode-N, ciliate protozoa-CP, flagellate protozoa-FP, and a mite-M. This soil can be a habitat of enormous complexity and diversity even over small distances. For example, the actual size of the soil in this drawing is < 1 mm in both directions yet may contain habitats that are acid to basic, wet to dry, aerobic to anaerobic, reduced to oxidized, and nutrient-poor to nutrient-rich. Realizing this complexity and diversity is the key to understanding soil microbiology. *Original drawing by Kim Luoma.*

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**FIGURE 3-16**

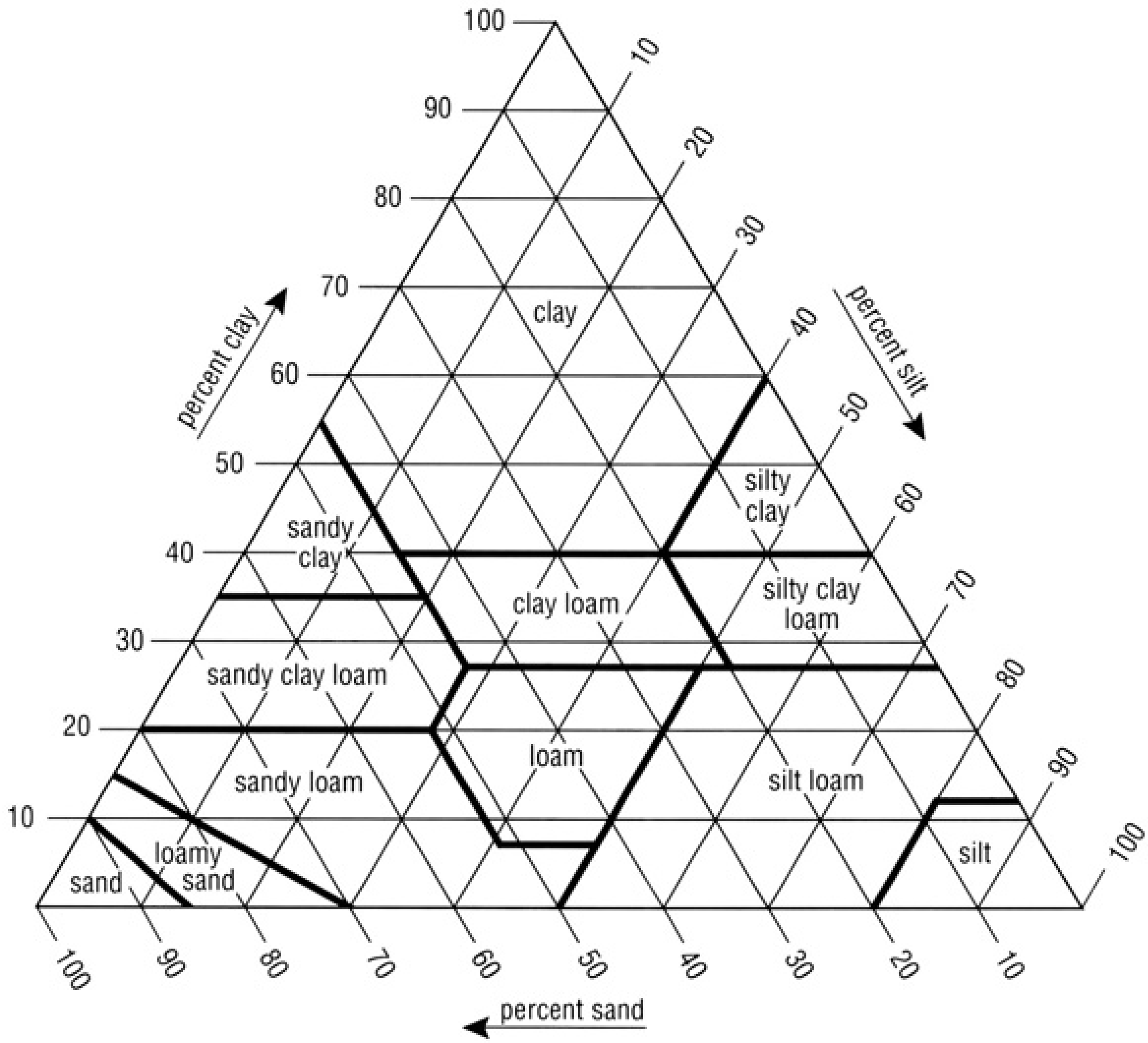


Chart showing the percentages of clay, silt, and sand in the basic textural classes.

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