Lab 10: Soils

Please Read and Bring With You to Lab
This worksheet is due next week at your consultation with your instructor.

What you should bring:

Notebook (for recording data; you will not turn it in) & pencil or pen.
This handout

What you will be provided:

Per group:
Small garden trowel
Sealable (zip-lock) plastic bag
Soil moisture/pH gauge
Soil test kit supplies and/or test strips
Dissecting microscope
Sample of soil mesofauna

Objectives:

- To evaluate key soil characteristics including texture, pH, moisture, and nutrients.
- To compare the soils of desert and landscaped areas on campus.
- To gain an appreciation for the functional and taxonomic diversity of the soil fauna.

Preparation:

Students should read this handout and Chapter/Section 2.1 "Soil: The Foundation of Terrestrial Biomes" and skim through Chapters 19 & 20 in Molles or similar text.

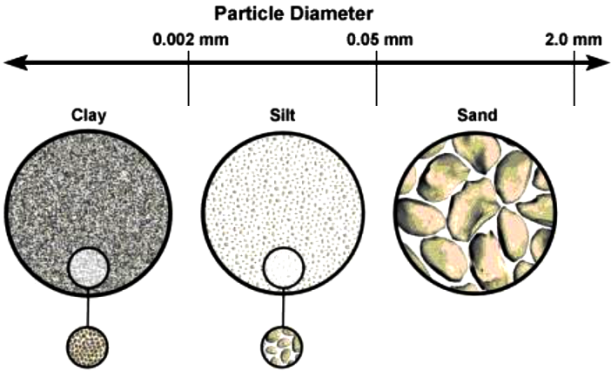
Introduction

Soil is one of the earth's most important resources. For a community of plants and animals to become established on land, soil must first be present. Further, soil quality is often a limiting factor for growth in many systems. Soil is a complex mixture of inorganic and organic materials, microorganisms, water and air. The weathering of bedrock produces small grains of rock that accumulate as a layer on the surface of the earth. There they are altered by biology, becoming mixed with organic matter, which results from the decomposition of the waste products and dead tissue of living organisms to form humus. The soil formation process is very slow (hundreds to thousands of years), so it can be very detrimental to a community if the soil is lost through erosion or its quality degraded by pollution or misuse.

As a class, we will identify various soil ecosystems on campus that we would like to examine further. Your group will be assigned to collect one of those samples. We will then measure a number of key characteristics of soil and see how they relate to habitat. Important soil characteristics include texture, pH, moisture, nutrients, and the soil biota.

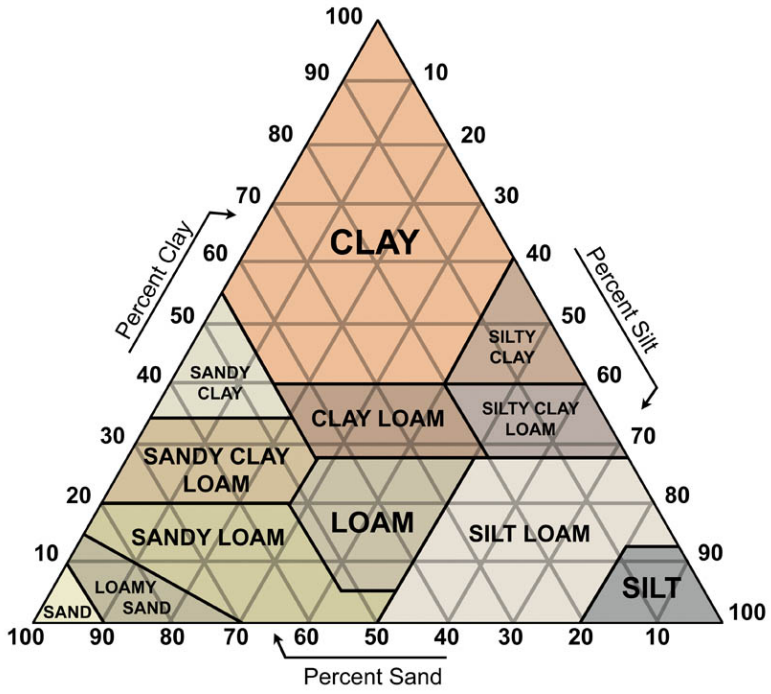
Soil Texture

Fig.1. Soil particle types based on size.



Soil texture refers to the proportion of sand, silt, and clay present in a soil. These three components differ in their particle size, with sand having the largest particles and clay the smallest (Fig. 1). The differences in particle size (and therefore surface area) influence water tension and pore space in the soil. Smaller particles have more surface area and thus are better able to bind to and retain water. Larger particles have more pore space (the gaps between particles) which provides better aeration. Thus, texture is an important physical property of soils that influences water percolation, aeration, animal habitat and plant growth.

Fig. 2. The soil textural triangle.



Most soils are mixtures containing a range of particle size classes. There are 12 soil texture classes ranging from sand to silt to clay at the extremes, with intermediate classes containing different amounts of sand, silt and clay. The 12 classes of soils based on the relative mixtures of these particles can be diagrammed on a soil textural triangle (Fig. 2). The right side of the triangle indicates percent silt, the bottom of the triangle indicates percent sand, and the left side of the triangle indicates percent clay.

Rather than measure particle size directly (which can take several days), we will use a tactile method to identify the texture type of your soil sample. Once you have done this, locate your soil type on the soil triangle:

Soil pH

Soil pH is a measure of a soil's health. It affects availability of nutrients, toxicity of certain elements in soil, and functioning of soil organisms. The optimum soil pH range for most plants is 6.0 to 7.0. If pH is too low (<6), the excess H^+ ions will displace nutrient ions such as Ca^{2+}, K^+, nitrates and phosphates and prevent them from binding to soil particles. This causes these nutrients to be more rapidly leached from the soil.

Low pH can also dissolve minerals such as Al, Fe, and Mn which can be toxic to plants. Low pH can also hinder bacterial growth, reducing rates of decomposition. On the other hand, high pH (over 7.5) can prevent some important minerals from dissolving and thus being available to plants.

Soil Nutrients

Soil contains important primary plant nutrients such as nitrogen, potassium and phosphorus. Nutrients tend to exist as ions that may be dissolved in water or attached to soil particles. Soils are also a hot-spot for nutrient cycling, where these nutrients are taken up by plants, to eventually be returned to the soil via decomposition. The amount of available nutrients in the soil is in part a product of the decomposer community and will influence plant growth. In lab, we will compare the availability of nitrogen in our soil samples.

Nitrogen (N) is one of the main essential nutrients for all life and is often the most limiting nutrient in soils. It is an essential component of amino acids (and thus proteins) and nucleic acids. It is available to plants in several inorganic forms, such as nitrates (NO_3), nitrites (NO_2), and ammonia (NH_4). Some plants, especially legumes (Family Leguminosae or Fabaceae), can harbor endosymbiotic bacteria in their roots that can "fix" nitrogen by converting relatively inert atmopheric N_2 into forms such as NO_3 that are usable to the plant. This gives them a considerable advantage as they are much less N-limited than plants without this capability. The primary source of soil nitrogen is the release of NH_4 from the decomposition of organic material by bacteria and fungi. Ammonia is less desirable to plants than other forms, but different sets of soil bacteria convert it fairly quickly to nitrites and then to nitrates. In most healthy soils (and aquatic environments) we would expect to find mostly nitrates and little ammonia.

The element phosphorus is available in soils in the form of inorganic phosphate (PO_4). Phosphate is a component of nucleic acids, phospholipids, and bone. It is usually the second-most limiting nutrient after nitrogen.

Soil Fauna

The soil is inhabited by a complex community of organisms that are incredibly numerous. There are millions of minute microbes, strange arthropods, insects and worms, even small mammals. Every step you take, you are stepping on hundreds of thousands of lives, many of which you'd never recognize. Through their activity, these biota influence important soil processes that are key for soil fertility. The soil biota can be characterized in a number of ways. The various soil organisms can be categorized by their functional role in the soil, as follows:

Decomposers — mostly bacteria and fungi that break down dead organic material and release inorganic nutrients. As their study requires specialized techniques, we will not examine these in today's lab.

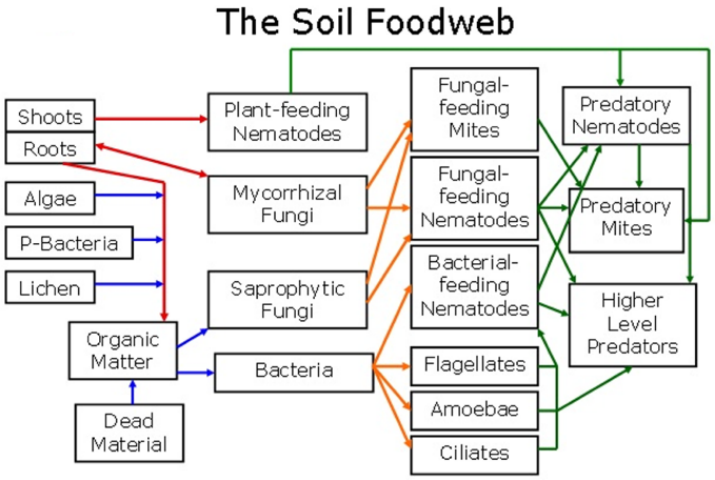
Microbivores (Bacterivores and Fungivores) — consume the decomposer microbes (bacteria and fungi); includes nematodes, mites, collembolans, etc.

Herbivores — eat living plant roots and shoots; includes nematodes, mites, and tardigrades.

Detritivores — eat detritus and whatever is on it, e.g. earthworms, millipedes, isopods, and some nematodes.

Predators — eat other animals; e.g. pseudoscorpions, centipedes, nematodes, mites.

Omnivores — eat a variety of foods; include symphylids, silverfish, barklice, etc.



The soil biota can also be characterized by size. The multicellular organisms (i.e., excluding bacteria and protists), fall into three size classes:

Microfauna — very small, microscopic organisms that live in water films of soil and litter. They are primarily microbivorous and incredibly numerous. They include nematodes, rotifers, and tardigrades.

Mesofauna are slightly larger (but for the most part still microscopic) organisms that live in the air-filled pore spaces in soil and litter. They include microarthropods (e.g. mites, collembolans), but also small segmented worms, large nematodes, and immature macrofauna. There are mesofauna represented in every functional role in the soil.

Macrofauna are large enough to see without a microscope and tend to be more mobile. They include earthworms, isopods, centipedes, millipedes, and various insects. Most macrofauna are not exclusively soil dwellers, and have either partial stages of their life cycle in the soil, or are active on the soil surface.

In lab, there will be mesofauna samples from several different locations around campus. These were collected prior to lab and animals extracted via Berlese funnel and other techniques. We will investigate the mesofauna extracted to compare the communities living in these different habitats and how this relates to other aspects of the soil.

Procedures

1. You will work in groups of ≈3 for this lab.

2. Collecting Soil Samples.

A. Each group will be assigned a specific habitat on campus from which to collect soils. Your instructor will direct you to a suitable location.

B. Set the switch on the soil gauge to "Moisture" and note which scale in the display represents moisture.

C. Insert the probe of the gauge to a depth of about 5 cm. Record the moisture reading on the gauge.

D. Switch the soil gauge to the "pH" setting and locate the pH scale in the display.

E. Reinsert the probe of the gauge to a depth of about 5 cm. Record the pH reading on the gauge.

F. Using a trowel, scrape a sample of soil to about 5 cm in depth and place this sample in your ziplock bag. Try to avoid damaging any landscaped plants.

G. Make note of the surrounding from where you took the soil sample. Note if plants are present, if there is significant human impact on the soil and how that area is used.

H. Return to the classroom with your sample and notes.

3. Soil Texture.

A. Take a small handful of soil from your sample into the palm of your hand. Make sure there are no larger particles like stones or bits of wood.

B. Mist the sample with water. If there is excess water, add a pinch more soil at a time.

C. Squeeze the sample. Does it form a ball or not? If not, add more water and try again to squeeze it into a ball. If you are unable to form a ball, you have **sand**. You do not need to proceed further.

D. If you were able to form a ball with the addition of more water, knead a marble-sized ball of soil until all aggregates are broken up.

E. Make a ribbon by squeezing the dirt flat between your thumb and forefinger, pushing upward with your thumb until it forms a ribbon. The ribbon should run past your forefinger and may be between 1 cm and 5 cm in length before it breaks off. Measure the ribbon and record its length. Also note if it feels gritty or smooth, or does not have a definite gritty or smooth feeling.

F. If the sample did not form a ribbon, you have **loamy sand**. You do not need to proceed.

G. If it did form a ribbon, classify your soil using the following table:

		Ribbon length		
		< 2.5 cm	2.5-5.0 cm	> 5.0 cm
Feel	gritty	**sandy loam**	**sandy clay loam**	**sandy clay**
	smooth	**silt loam**	**silty clay loam**	**silty clay**
	neither	**loam**	**clay loam**	**clay**

4. Soil Nutrients: Nitrogen

A. We will test for several forms of Nitrogen using simple color-changing test strips such as those used for testing nutrient levels in ponds and aquaria (where too much nutrient can lead to algae growth).

B. We will test for ammonia (NH_3), nitrite (NO_2) and nitrate (NO_3).

C. Fill a test tube about 1/3 full of crushed soil, and add an equal amount of distilled or deionized water. Thoroughly shake the mix and let it settle. Once the water becomes somewhat clear, briefly insert the test strip for about 5 seconds.

D. Remove the test strip and hold it horizontal, with the test pad up, for 60 seconds. Compare the color on the test pad to the color chart on the side of the container.

5. Soil Mesofauna

A. Obtain a sample of soil invertebrates that have been extracted from soil collected in the same area as your sample.

B. Examine the sample under a dissecting scope.

C. Count the total number mesofaunal animals that you can find and record this number.

D. Identify the major morphospecies (e.g. mite, collembolan, coleopteran, etc.) of soil invertebrates that are present in your sample, using the visual keys provided in lab. Record the morphospecies richness of your sample.

6. Class Data

A. Summarize all of your observations in the table below, and then transfer the data to the computer.

B. The class data will be posted later today.

Variable	Your Observation
Location (habitat, plant types)	
Land use (natural or landscaped)	
Soil moisture (no units)	
Soil texture type	
Soil pH	
Soil Ammonia (NH_4) (ppm)	
Soil Nitrites (NO_2) (ppm)	
Soil Nitrates (NO_3) (ppm)	
Soil biota total abundance	
Soil biota species richness	