Soil in your backyard: activities that you can do to determine local soil health and composition

"A lesson that can be conducted at home for high school students developed by Project Terrapin LLC in response to diamondback terrapin research conducted in New Jersey"

This lesson focuses on the properties of soils and can be conducted in any part of the country, in the front or back yard and in the field. This lesson will allow you to use household items to look at some classic properties of soil composition and human impacts on soil health. We will look at particle composition, soil compaction and the effect of compaction on water moving through the soil. For us at Project Terrapin, soil health and composition (Fig.1) is important as soils are a used to hold and incubate diamondback terrapins (Fig. 2) eggs that eventually hatch after incubating for two to three months. Many other turtle species bury eggs in the soil where they are incubated. The incubation time is affected by soil temperature and moisture, which is a key to successful hatching (called hatching success). Properties of soil including compaction and sand particle composition are key determinants in the incubation process so that the soil moisture and gas balance in terrapin nests remain conducive for embryos incubating. Beside successful incubation, soil compaction plays a role for terrapin hatchlings exiting the nest cavities and emerging after they successfully hatch (Fig. 3). Once again, this is important for other turtle species as well that dig below surface nests. Habitat loss is a problem for nesting female turtles in general, since the loss of nesting areas is leading to the selection of less desirable nesting habitats. For example, diamondback terrapins are known to soils covered with gravel and other materials. Therefore, understanding soil type and soil conditions are important in altered areas to see if those conditions can support successful development of eggs. If the soil is too dry and/or does not provide a moisture balance, then the eggs can lose moisture and dry out; this is called desiccation (Fig. 4). This can happen to plants as well, where roots cannot uptake the proper amount of moisture for the plant to function. This is dependent on salt content in the soils, which has an affect on moisture balance. There can also be excess organic materials in the soil that can bind and hold moisture from getting to plant roots. We will take a look at some properties of soil that you can measure in terms of soil composition, and porosity. It will include classifying soils using the sand, silt and clay designation (Wentworth Soil Classification). Based on this, you can determine if the soil has the correct composition for certain functions, such as growing plants, vegetables, or used for an area to drain.

Fig. 1. Sand-soil type at an area where diamondback terrapins nest along coastal areas.

Fig. 2. Research assistant Kiran Sinha monitors a terrapin nest that was just dug within the same day at the Long Beach Island Foundation of the Arts and Sciences, NJ

Fig. 9. Diamondback terrapin hatchlings emerging from a nest. Notice the sand composition and terrapins moving up through the sand through the nest cavity.

Fig. 4. Dried out, desiccated, diamondback terrapin eggs that we in soil that was high in salt content, thus affecting the egg moisture content.

Soil Composition: The Wentworth Soil Classification System (1922) is used to determine soil particle composition including sand, silt and clay. Depending on the volume of sand per total volume of the sample, a fraction can be determined, the same can de determined for silt and then clay can be induced based on the other compositions. For example, if 20 ml of soil were separated and 15 ml were determined to be sand and 4 ml silt, then the sand fraction would be calculated as 15/20 = 75 (sometimes it is written as a percentage). The silt fraction would be calculated at 4/20 = 20 (sometimes referred to as 20%) and it could be deducted that the sand fraction would be 1/20 = 5 (sometimes referred to as 5%). If we use the soil texture triangle (Fig. 5), we can follow the fractions to find the designation. From this calculation, it would name the soil "loamy sand", which means more sand than loam, which is silt broken down into smaller particles. There is another tool on-line that you can use to designate soil texture composition using the US Department of Agriculture's –Natural Resources Conservation Service ["Soil Texture Calculator"](). You need to enter the fractions as percentages for sand and clay. Based on our example above it confirmed our prediction using the Soil Texture Triangle as "Loamy Sand" (Fig. 6).

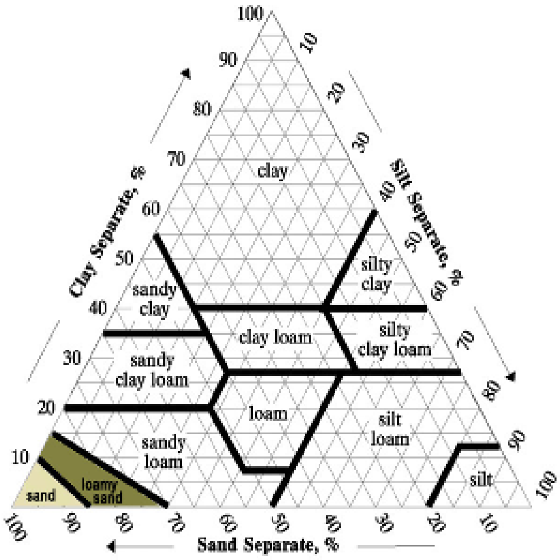

Fig. 5. Soil Texture Triangle that you can use to intersect the fractions of sand (bottom), silt (right) and clay (left).

Fig. 6. A photo of soil taken from Ocean County, NJ that was determine to be "Loamy Sand" at a diamondback terrapin nesting site.

Soil composition is important as it is considered a condition for microhabitat (Fig. 7) for species in soils. Soils consist of nematodes, insects and other burrowing organisms that live in soil. On beaches, there are organisms that burrow into the sand called mole crabs (genus *Emerita*) that move within the sand close to the breaking water in the "surf zone". Organisms that live in sand or bottom sediment (sometimes considered "sub-aqueous soils" or substrate) are called "meiofauna". Composition is important to allow spaces for such organisms to move within the soil, thus soil particle size composition is an important factor as well as compaction.

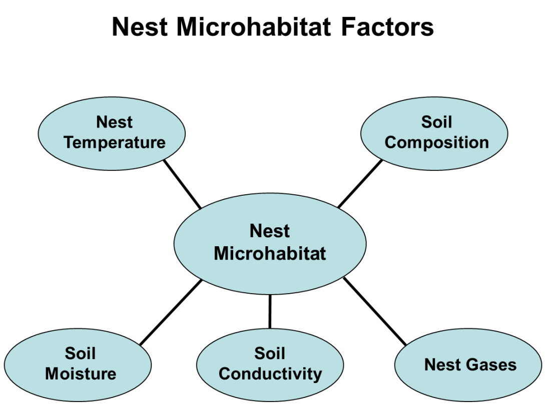

Fig. 7. Soil nest factors, considered microhabitat factors, for diamondback terrapin eggs, where composition is one of the key aspects.

Soil Compaction: As stated above, the space within soil particles is important for soil function for many reasons including gas exchange for organisms living in the soil, infiltration of water into the soil and movement of water down through the soil called percolation. This is especially important in available water for plants through root systems. Another aspect of soil compaction is porosity, which allows for water to move down

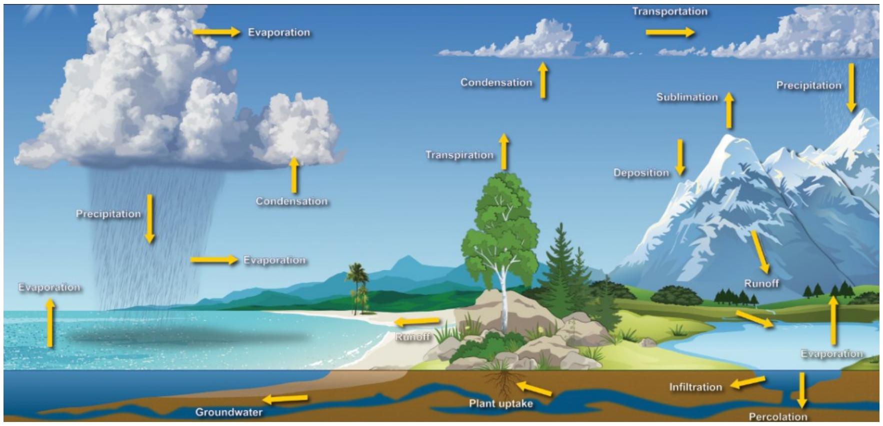

Fig. 8. The Water Cycle showing infiltration of water into the ground and percolation deep into aquifers (sometimes referred to as "ground wells"). Image was taken from NOAA education resources on-line).

Though the soil to eventually reach aquifers to "recharge", or replace, the water that is taken from them for multiple purposes. Aquifers are a source of drinking water, used to water plants in agriculture and provide additional water resources. According to NOAA, about 30 percent of the freshwater on earth is found in groundwater; whereas a majority of the freshwater is found in polar ice that is difficult to utilize for drinking water purposes. It is estimated that over 1.5 billion people on earth depend on groundwater as their primary drinking water source. Thus, recharging groundwater is important in maintaining the water cycle and to provide the necessary water that is needed. The process starts with recharging our aquifers with rainwater. The soils act to filter contaminants and nutrients as the water moves (percolates) through the soil.

Normally, we can use a soil texture kit to analyze the composition of soil; however there are other ways that we can measure soil composition using household items and trying to be as accurate as possible. The key is to use something that has volume measurements or something that is plastic and transparent that is cylindrical (total cylinder from the top down and at least six inches tall—15 cm). You will need to get a soil sample from a location in your area. Using the materials on the right, you need the following items bolded. If you have a cylindrical, plastic object, or Mason Jar (Fig. 11) then use the items not bolded under the materials list in addition to the bolded items.

Fig. 9. Soil texture kit that separates soils into sand, silt and clay fractions.

Soil Composition Materials Needed

- ⇒ **Measuring cup (if at home use a measuring cup in ounces and then conversion can be calculated, some are in ml).**
- ⇒ **Garden shovel or trowel**
- ⇒ **Small container to hold soil after collected**
- ⇒ **Clock/phone with seconds**
- ⇒ **Plastic wrap to put on top of the measuring cup. Rubber band may be helpful**
- ⇒ Ruler (metric in cm)
- ⇒ Transparent or invisible tape
- ⇒ Permanent marker or pen

1) Take a soil sample using a garden shovel of trowel and place into a container.
2) Add 1/3 cup of soil to the measuring cup and then add water (tap) to the 1 cup line (1 past soil to 2 parts water).
3) Cover the measuring cup with plastic wrap to make a tight seal.
4) Shake the contents of the soil and water and let settle for 30 seconds (get a measurement which is sand).
5) Note the level and wait for 1 more hour and note the volume of the 2nd level of settled soil which is silt, and then **see #6—#8 on the next page**.

Soil Investigation

If using a plastic, cylinder then perform the following procedure:

1) Place a piece of transparent or invisible tape from the very bottom to the top of the cylinder.
2) Using a centimeter or millimeter ruler, mark the tape from the bottom up with 1 cm increments using a permanent marker or pen.
3) Once marked, use a garden shovel or trowel and take a soil sample (place into a container).
4) Fill the soil to the 5 cm line and add water (tap water) to the 15 cm line.
5) Use a piece of plastic wrap to form a seal over the cylinder and shake the soil and water until all of the soil is suspended (also you can use a rubber band around the plastic).
6) After 30 seconds, measure and note the line that the sand settles which is considered your sand fraction.
7) Wait 1 hour and determine the measurement over which the second layer settles, which is silt and will be considered the silt fraction (Fig. 10).
8) Please pour off the water and soil when completed back outside.

Calculating the Fractions

If using the measuring cup, then you need to calculate how many ounces of sand settled out of the original amount and this is your sand fraction. After one hour, try to determine how much silt settled in the measuring cup which may be a challenge. The amount of silt over the initial amount of total soil is considered your silt fraction. The difference is assumed to be clay.

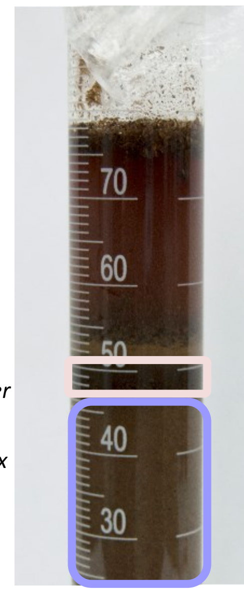

Fig. 10. Notice the sand layer (blue box at the 46 mL line) and the silt layer (lighter box which measured 3 mL of volume). Image courtesy of Forestry Suppliers

Using a cylinder, take the amount of sand in cm over the initial 5 cm used (if you use mm it may be more accurate). After 1 hour, take the amount of silt and divide it by the 5 cm mark (you may have to use a mm ruler to get an accurate measurement and convert (Fig. 12). This will be your silt fraction.

To get clay fraction, please add the sand and silt fraction and subtract from the initial. For example if we obtained 4.0 cm sand and 0.5 cm silt, then the assumed is 0.5 cm clay. This would calculate to 80% sand, 10% silt and 10% clay. Using the [Soil Texture Calculator](), you can determine the **soil classification type**.

The challenge will be using a measuring cup since the measurements may be in ounces and some cups have a ml conversion on the other side of the measuring cup that will make volumes easier to work with. The rule of thumb is to use two parts of water to one part of soil.

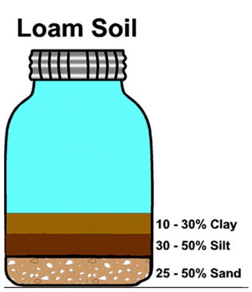

Fig. 11. Mason jar with separation showing sand, silt and clay layers. Clay can take a lot longer to settle and without a floccuant, it can take days and weeks to settle. Image courtesy of Utah Education Network

Fig. 12. See measurements in inches on a plastic cup. A cylindrical plastic container works best for this experiment. Image is courtesy of Rachio

Measuring Soil Compaction

Fig. 13. Measuring water infiltration in soils with a visual demonstration by Life Green Systems.

Soil compaction leads to less water being able to infiltrate soil and it leads to increased runoff and less water reaching the aquifers. There are many ways to determine compaction, one of which is using a handheld soil penetrometer. One way to determine soil compaction is to measure soil infiltration with a known amount of water. It is usually measured in mm water/hour. It is important to understand since rainfall events are important in providing water back to the aquifers, but the process needs to start with the soil surface (Fig. 13). An easy way to determine soil infiltration is demonstrated using this video.

Soil Infiltration Materials Needed

⇒ **A cylinder like 3 inch or wider PVC piece at least 15 cm tall, or coffee can**

⇒ **Ruler (cm) with mm increments**

⇒ **Permanent marker to make marks on PVC or can**

⇒ **Pitcher or bucket of water**

⇒ **I-phone or stopwatch**

⇒ **Hammer or sledge small sledge hammer**

⇒ **Small 2” x 4” lumber piece to cover the entire width of the PVC or can**

⇒ **Gardening or work gloves**

1) Find a piece of wide PVC pipe (3 inch diameter or wider) or coffee can with the bottom cut out (be careful using a metal coffee can).

2) Take a ruler and make 2 cm increments using a permanent marker starting at top down to the bottom on the inside of the PVC piece or coffee can. Be sure to make the marks highly visible.

3) Find an area outside that you want to test the infiltration rate and then push the cylinder into the surface (twist it first to break the surface). **Be sure to wear your gloves!**

4) Pour water (tap water) from the bucket or pitcher into the cylinder to make sure that it is full and immediately time the movement of water from one 2 cm mark to the next. Keep a log of those times between each mark in seconds.

5) Between each mark is the infiltration rate of water (20 mm per time in seconds). You can take an average for each interval.

If the water infiltrates the soil too quickly, then take the time it moves down through multiple marks. For example, if it moves down 4 marks in 20 seconds then is would be 8 cm (80 mm) per 20 seconds. You can then convert this to mm/hour. One rule of thumb is that the more clay you have, the more compacted the soil and the slower the infiltration rate. **In coastal New Jersey, we have high sand fractions, thus should have faster infiltration rates that can be measured in mm/second or mm/minutes.**

Table 1. Soil textural types and infiltration rates (highlighted) in mm/hours. Data provided by Research Gate.

Texture class	Effective water capacity (Cw) (mm)	Infiltration rate (f) (mm/hour)	Hydrologic soil grouping
Sand	8.89	210.1	A
Loamy sand	7.874	61.2	A
Sandy loam	6.35	25.9	A
Loam	4.826	13.2	B
Silt loam	4.318	6.9	B
Sandy clay loam	3.556	4.3	C
Clay loam	3.556	2.3	D
Silty clay loam	2.794	1.5	D
Sandy clay	2.286	1.3	D
Silty clay	2.286	1.0	D
Clay	2.032	0.5	D

Investigation Questions

1. Please choose three locations in your backyard or around your neighborhood to gather soil samples and to use for the infiltration activity. Please choose areas that have a high degree of human use like a pathway versus an area by vegetation and trees. Please complete the following table….

Soil Sample	Sand Fraction	Silt Fraction	Clay Fraction (Estimated)	Soil Texture Classification	Infiltration Rate in mm/hour
Location 1 ______________					
Location 2 ______________					
Location 3 ______________					
Averages					

2. Was there a difference between areas where there is vegetation growing and areas where there is a lot of human activity (i.e, walking paths, sports fields)? If so, please explain some of the reasons why?

3. Was there a difference in sand composition in some of the areas? If so, did the sand composition show a correlation with the infiltration rate? Please explain.

4. Please explain how soil micro-environmental factors play a role in the survival of a species other than a diamondback terrapin. Please explain which soil factors play a role and how and support your answer.

5. How is Climate Change going to impact soil function? Please provide a response and support your answer by using a documented source.

Standards and References

This lesson incorporated the following Next Generation Standards for High School:

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

Mathematics: MP.2; HSN.Q.A.3
Language Arts: RST 11-12.2

ESS3.D: Global Climate Change: Determine how earth's system is affect by Climate Change

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

Mathematics: MP.2; HSN.Q.A.3
Language Arts: WHST.9-12.7

Acknowledgements

The author wishes to acknowledge the Marine Academy of Technology and Environmental Science's soil laboratory and the Ocean County Soil Conservation District for information on soil health.

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