Filtering Qualities of Soils

Field Biology

Adapted from a lesson designed by Dr. Larry P. Wilding of Texas A&M University

For this activity, your job is to determine how different types of soils interact with different types of nutrients. The soils you will have available to you are a sandy soil (from the Willamette River) and a clayey soil (from CV's campus). You will also have two dye solutions – an orange solution that will simulate nitrates (NO_3^-), and a blue solution that will simulate ammonium (NH_4^+). You should work in groups of 3-4, but collect data and answer the questions individually.

The following facts are very important:

a. Most soil particles are slightly negatively charged.
b. Clay particles, in general, are more negatively charged than sand particles.
c. Opposite charges attract, while like charges repel each other.
d. The orange dye you are using has a negative charge associated with the orange color.
e. The blue dye you are using has a positive charge associated with the blue color.

For this activity, you should wear lab aprons, gloves, and safety glasses. If you spill any dye, clean it up with soap, water, and paper towels right away. Let an instructor know if you get any dye on your clothing or skin. These dyes are not caustic (dangerous) but they will stain virtually anything they come in contact with.

In order to evaluate each soil's ability to absorb the dyes, you will need to prepare some materials.

a. You should grind up a small (tablespoon) amount of soil using a mortar and pestle. You can also try using one of the coffee grinders. Don't stop grinding until your soil is completely broken up.
b. Cut a coffee filter to fit into a funnel, place the funnel into a flask, and place your soil in the funnel.
c. Prepare a data sheet. You should have columns for the soil type (CV or River), the dye color (orange or blue), and observations. (See below for an example.)

Soil Type	**Dye Color**	**Observations**
CV	Orange	Water coming out was much more clear than water going in
River	Orange	Water coming out was more clear than water going in, but not as clear as CV soil

d. Add the colored water to your soil using a pipette – work slowly, to avoid spilling the water and to avoid having it go over the top of the filter and into the flask.

Your primary task is to determine which of these two soils absorbs the most and the least of each of the two dyes. The measurements / observations you make will consist of comparing the color of the water flowing out of your soil to the color of the water you put into the soil. You'll also want to compare the color of the water flowing out of one type of soil to the color of the water flowing out of the other type of soil. You will need to repeat your measurements a few times in order to verify your results. There are only a limited number of flasks and funnels, so you'll need to reuse your materials – however, you can have two flasks at any given time (for comparison purposes).

If you have enough time before clean-up, you can try diluting the solutions to see if it's possible for any of the soils to completely absorb the either of the dye colors. If you put colored water into the soil and completely clear water flows out, you've done it!

Questions:

1. Which soil / color combination had the clearest solution collected? Which soil / color combination had the darkest solution collected? Do these observations match with the predictions you made in class on Friday?
2. Why might these dyes filter out more from some soils than other soils? Remember that the colored part of the blue dye is positively charged and the colored part of the orange dye is negatively charged particles.
3. Most of the plant nutrients (except nitrates and phosphates) are cationic (positively charged), and soils are mostly anionic (negatively charged) and the soil clays and organic matter are mostly anionic. Why do you think this combination of charges is helpful for plants?
4. Considering question 3, what does this tell you about nutrients that are negatively charged (like nitrates)? Would they be retained in soils, or would they be more mobile and move wherever water moves in the soil system? Explain your response.
5. What does this activity tell you about the potential pollution of groundwater (underwater lakes and pockets of water) if excess soil nitrogen fertilizers were applied to lands for crop production, or fertilizers were applied to lands when a crop was not actively growing and extracting nitrates (for example - fertilizing cropland in the early fall of the year when plants aren't growing)?
6. (If you got this far …) Which dyes were you able to get the soils to completely absorb? How much did you have to dilute the dyes to get the soils to absorb them completely? What does this tell you about the amount of nutrients that soils can hold in them?