Filtering Soil Qualities

Duration: 1 class period

Group Size: 10-25 students

Setting: Classroom or Laboratory

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The purpose of this activity is to provide students with hands on experience in collecting data and working with team members while applying concepts used in the classroom to the field.

Goals:

Students will:

- Conduct a basic laboratory experiment examining soil particles
- Examine ecological effects of different soils and soil textures in terms of their ability to hold or lose soil nutrients.
- Examine ecological effects of different soils and soil textures in terms of their ability to hold or lose potential pollutants that are incorporated to soils.
- Learn how to work together in groups to solve problems.

Materials Needed:

- Three soils of clayey, loamy and sandy texture and one organic-rich soil -- about 1/2 cup (120 grams) of each soil
- Methylene blue dye powder or other cationic form dye -- about 1/3 oz. (10 grams)
- Tap water -- about 1 quart (1000 mL)
- Four Whatman # 42 paper filters -- about 4-inches (11-cm) in diameter
- Four 4-inch (11-cm) diameter plastic or glass funnels
- Four pint-size (400 to 500 mL) plastic or glass beakers or jars
- Four 1/2 pint (250 to 300 mL) clear glass tumblers or clear plastic drinking cups to fit inside the above beakers or jars
- Wood block of large enough size to crush soil or a mortar and pestle
- Plastic squirt bottle about one pint (500 mL) in capacity

Process:

1. Dry the soil at room temperature for several days if moist.
2. Crush the soil with a wood block or mortar and pestle to a fine powder.
3. Place a 250 to 300 mL clear glass receiving vessel (glass tumbler or plastic drinking cup) inside the larger 500 mL glass (or plastic) beaker or jar.
4. Place a filter paper inside a funnel and fill the funnel about 1/2 full with crushed soil.
5. Place the funnel containing the crushed dry soil on top of the 500 mL beaker (or jar) such that the stem of funnel fits inside the smaller receiving vessel inside the beaker (or jar).
6. Prepare the dye solution in the squirt bottle by mixing 10 grams of dye with 500 mL of tap water.

7. Add to each soil in the funnel enough dye solution to wet the soil plus just a little extra.
8. Wait about 10 minutes (may take longer for the clayey and organic-rich soil) for the dye solution to filter through the soil.
9. Remove the filtered dye solution that was caught in the receiving vessel inside the beaker and place it beside the soil used as a filtering medium.

Observations and Interpretations:

1. Note which soil was associated with the clearest solution collected. It should have been the clayey and organic-enriched soils with the sandy soil having the least dye removed.
2. Why was the dye filtered out more from some soils than other soils? Remember the dye chromophore (colored part of the molecule) is cationic (positively-charged ion) and soil clays and organic matter are anionic (negatively-charge) particles.
3. If one considers that most of the plant nutrients (except nitrates and phosphates) are cationic (positively- charged ions) and the soil clays and organic matter are mostly anionic, how does this explain how soils adsorb plant nutrients?
4. What would have been the results from this experiment if we had used anionic dye solutions to filter through the soil (those in which the color chromophore is negatively charged.
5. Considering question 4, indicate what you would predict about the response of nitrates (negatively-charged anions) in soils? Would they be adsorbed to clay and organic matter components or mobile and move wherever the soil solution moves in the percolating system?
6. How would this demonstration relate to potential pollution of groundwater aquifers 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 (e.g. fertilizing cropland in the early fall of the year)?
7. How does this demonstration illustrate that soils are an electrical system? Remember like ionic charges repel each other and unlike charges attract each other.
8. Note the illustration of this principle using two small electrical magnets and relate to the soil components. What is the charge on most clay particles in soils versus the charge on most plant nutrients? Considering this why does the nutrient retention of a soil increase with clay and organic matter contents?
9. Consider this principal in the remediation qualities of soils and their ability to buffer against chemical pollution and filter water percolating through soils. Also, consider this effect in terms of the probable biocycling of pollutants adsorbed to colloidal surfaces and the long-term clean up of soils polluted with chemicals.

References:

http://soil.gsfc.nasa.gov/filter/filter.htm