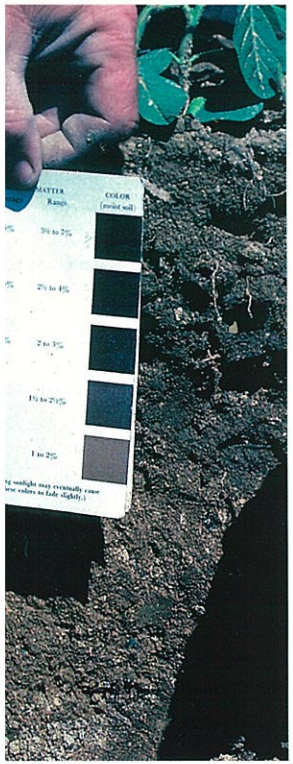
LEARNING ACTIVITY:

Soil Color and Redox Chemistry

Grade Level: 9-12



Soil Science Society of America

Source: Soil Science Society of America. Adapted with permission.

Are soils like M&Ms®? Yes! Typical soil colors are red, brown, yellow, or black. These colors are often not the color of the minerals in the soil but coatings of iron oxides (Fe_20_3, FeOOH, and so on) or organic matter on particles. The minerals beneath are often quartz or feldspar, which are grey.

To see how coating affects soil color, consider red M&Ms®. If you place a few in a sieve, slowly immerse them in water, and gently shake them, the water will turn pink as the red dye is washed off. If you remove and dry them, you can see they are now white.

A similar process occurs in saturated soil when Fe^{3+} is reduced to Fe^{2+} due to a microbial mediated redox reaction. If air, which contains oxygen (O_2), is in the soil, the soil is aerobic.

$4e^- + O_2 + 4H^+ \rightarrow 2H_2O$

If all O_2 is removed, soil becomes anaerobic (saturation occurs).

Denitrification (no color change):

$10e^- + 12H^+ + 2NO_3 \rightarrow N_2 + 6H_2O$

Iron (Manganese) Reduction (soil turns gray):

$2e^- + 6H^+ + Fe_2O_3 \rightarrow 2Fe(II) + 3H_2O$

Why is this reaction important? Soil scientists can identify where the water table is even when the soil is not saturated. Consider the M&Ms® again. What is the chance that the now-white ones will turn red again? Slim to none. Soil is the same. Once the red (rusty) colors due to iron oxides have been removed and the soil is gray, it is unlikely that the particles will become coated (turn red) again.

This reaction occurs in saturated and reduced or anaerobic conditions. Thus, the presence of gray colors indicates the water table. This helps soil scientists identify wetland or hydric soils, as well as locate suitable soils for septic systems and related land use. The reaction only occurs if there are sufficient numbers of microbes and a food source (carbon) present to cause anaerobic conditions to occur. To better understand, observe iron reduction in the following activity.

Materials

- Red, yellow, or brown soil
- 2 or more pint mason jars with lids
- Water
- Sugar
- Autoclave or water bath
- Paper and pen to record observations

Procedure

1. Fill each jar about halfway with soil.
2. Add at least one tablespoon of sugar (or another carbon source such as saw dust, corn syrup, and grass clippings).
3. Fill each jar with water to within 1/4 inch of the top.
4. Put lids on jars and shake to mix well.

5. Autoclave one jar, following the instructions for autoclaving liquids. If an autoclave is not available, follow the USDA methodology for home canning (www.uga.edu/nchfp/publications/publications_usda.html). Be sure to follow all safety precautions, including washing your hands when you finish.
6. Allow the jar to cool.
7. Let the jars sit and observe changes over a few weeks.
8. Record observations, particularly color changes and bubbles.
9. You should see little to no changes in the autoclaved sample, as the microbes have been killed by the heat. In the other jars, bubbles will start to form and over time the soil will turn gray. This may take longer in some soils due to the amount of iron, food, and microbes in the soil.

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
1	2	3	4 Independence Day	5	6	7
8	9	10	11	12	13	14 **Happy Birthday!** Florence Bascom, U.S. Geologist, First American Female Ph.D., Born 1862
15	16	17	18	19	20 **Did You Know?** U.S. Apollo 11 Astronaut Neil Armstrong Becomes First Human to Walk on Moon, 1969	21
22 Parents' Day	23	24	25	26	27	28
29	30 **Happy Birthday!** Marie Tharp, U.S. Geologist, Sea Floor Cartographer, Born 1920	31				