**Interpreting Soil Color**

Color can be used as a clue to mineral content of a soil. Iron minerals, by far, provide the most and the greatest variety of pigments in earth and soil (see the following table).

**Properties of Minerals**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Mineral** | **Formula** | **Size** | **Munsell** | **Color** |
| goethite | FeOOH | (1-2 µm) | 10YR 8/6 | yellow |
| goethite | FeOOH | (~0.2 µm) | 7.5YR 5/6 | strong brown |
| hematite | Fe2O3 | (~0.4 µm) | 5R 3/6 | red |
| hematite | Fe2O3 | (~0.1 µm) | 10R 4/8 | red |
| lepidocrocite | FeOOH | (~0.5 µm) | 5YR 6/8 | reddish-yellow |
| lepidocrocite | FeOOH | (~0.1 µm) | 2.5YR 4/6 | red |
| ferrihydrite | Fe (OH)3 |  | 2.5YR 3/6 | dark red |
| glauconite | K(SixAl4-x)(Al,Fe,Mg)O10(OH)2 |  | 5Y 5/1 | dark gray |
| iron sulfide | FeS |  | 10YR 2/1 | black |
| pyrite | FeS2 |  | 10YR 2/1 | black (metallic) |
| jarosite | K Fe3 (OH)6 (SO4)2 |  | 5Y 6/4 | pale yellow |
| todorokite | MnO4 |  | 10YR 2/1 | black |
| humus |  |  | 10YR 2/1 | black |
| calcite | CaCO3 |  | 10YR 8/2 | white |
| dolomite | CaMg (CO3)2 |  | 10YR 8/2 | white |
| gypsum | CaSO4× 2H2O |  | 10YR 8/3 | very pale brown |
| quartz | SiO2 |  | 10YR 6/1 | light gray |

Relatively large crystals of goethite give the ubiquitous yellow pigment of aerobic soils. Smaller goethite crystals produce shades of brown. Hematite (Greek for blood-like) adds rich red tints. Large hematite crystals give a purplish-red color to geologic sediments that, in a soil, may be inherited from the geologic parent material. In general, goethite soil colors occur more frequently in temperate climates, and hematite colors are more prevalent in hot deserts and tropical climates.

Color - or lack of color - can also tell us something about the environment. Anaerobic environments occur when a soil has a high water table or water settles above an impermeable layer. In many soils, the water table rises in the rainy season. When standing water covers soil, any oxygen in the water is used rapidly, and then the aerobic bacteria go dormant. Anaerobic bacteria use ferric iron (Fe3+) in goethite and hematite as an electron acceptor in their metabolism. In the process, iron is reduced to colorless, water-soluble ferrous iron (Fe2+), which is returned to the soil. Other anaerobic bacteria use Mn4+ as an electron acceptor, which is reduced to colorless, soluble Mn2+. The loss of pigment leaves gray colors of the underlying mineral. If water stays high for long periods, the entire zone turns gray.

When the water table edges down in the dry season, oxygen reenters. Soluble iron oxidizes into characteristic orange colored mottles of lepidocrocite (same formula as goethite but different crystal structure) on cracks in the soil. If the soil aerates rapidly, bright red mottles of ferrihydrite form in pores and on cracks. Usually ferrihydrite is not stable and, in time, alters to lepidocrocite.

Along seacoasts, tide waters saturate soils twice daily, bringing soluble sulfate anions. Anaerobic bacteria use the sulfate as an electron acceptor and release sulfide (S2-) which combines with ferrous iron to precipitate black iron sulfide. A little hydrochloric acid (HCl) dropped on this black pigment quickly produces a rotten egg odor of hydrogen sulfide (H2S) gas. Soils that release H2S gas are called sulfidic soils. With time, iron sulfide alters to pyrite (FeS2) and imparts a metallic bluish color. If sulfidic soils are drained and aerated, they quickly become very acid (pH 2.5 to 3.5), and a distinctive pale yellow pigment of jarosite forms. This is the mark of an acid sulfate soil that is quite corrosive and grows few plants.

Galuconitic green sands form in shallow ocean water near a coast. They become part of soils that form after sea level drops. White colors of uncoated calcite, dolomite, and gypsum are common in geologic materials and soils in arid climates. A little carbonate dissolves in water, moves downward, and precipitates in soft white bodies or harder nodules. It also accumulates in root pores as lacy, dendritic (tree-branch) patterns.