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# Sticking to It

**How nutrients are affected by soil texture**

**OVERVIEW**

Soil nutrients and pH are important for plant growth. Measuring soil nutrients and pH are important. Using these protocols will help students appreciate chemistry in real life applications. Soil texture also is important. Soil particles have properties that are important for chemistry. This lesson will relate soil texture to nutrients.

**OBJECTIVES**

At the conclusion of the lesson, students will be able to:

* Identify ions
* Make the Lewis structures for these ions
* Understand how electronegativity is important for soil nutrients

**LENGTH OF LESSON**

Using the soil nutrient and pH protocols will take one 40 minute class period.

**GRADE LEVELS**

High School

**STANDARDS COVERED**

C5.5c Draw Lewis structure for simple compounds

**MATERIALS**

See soil nutrients and pH for materials

Sticking to It PowerPoint

**BACKGROUND**

Electronegativity is an important aspect of chemistry and biology. Certain atoms can attract electrons to itself. Biological molecules have polar and non-polar regions which determine how the molecules behave. We can extend this to soil in the BEST plots.

Soil is composed of many materials. Parts of soil are broken down rocks. Soil is made of different size classes (sand, silt and clay). Clay is especially interesting because of its tiny size and high surface area. This creates lots places for charge and it interacts with the other parts of the soil. Soil is also composed of decomposing plant material. Some of the decomposing plant material is lignin, which plants use to provide it rigidity. Humus and lignin are molecules that are difficult for bacteria to break down. The molecular structure also explains why soil has a net negative charge. There are areas on lignin that have a net negative charge. There are other minerals and ions in the soil. All these components are important for determining how available nutrients are to plants.

Plants need some elements in large quantities. Plants need tons of carbon, oxygen and hydrogen, but these usually available in abundance. Plants need nitrogen and phosphorus too. Many of the nutrients that plants need to grow are often **ions** in soil, and their properties can explain why certain nutrients are available or not available. Phosphorus is considered to be “sticky.” and there is usually lots of phosphorus in soil. Phosphorus is almost always in the form of phosphate and it interacts with many different ions in soil. Phosphorus is often in soil, but may not be available to plants. Some plants form mutualisms with mycorrhizae to get their phosphorus.

The chemistry of nitrogen is different from phosphorus. Nitrogen is often considered to be limiting, meaning that there is enough of other nutrients ([phosphorus](http://en.wikipedia.org/wiki/Phosphorus), [potassium](http://en.wikipedia.org/wiki/Sulfur), calcium, et al.,) but not enough nitrogen. We will measure nitrogen on the BEST plots because it is considered to be limiting.

Nitrogen is needed for proteins, enzymes, nucleic acids (DNA and RNA) and chlorophyll. Plants contain 1% to 6% nitrogen by weight and absorb N as both nitrate (NO3-) and ammonium (NH4+). Plant growth is often improved when the plants are nourished with both NO3- and NH4+ compared with NO3- or NH4+ alone. Some plants prefer on form over the other. Also bacteria need nitrogen to grow, so nitrogen can be found in bacteria. Some bacteria use nitrogen to “breathe,” using nitrogen and releasing N2 or a greenhouse gas, nitrous oxide. The nitrogen cycle involves lots of forms of nitrogen with different ions.

Remember that soil has a net charge which is important for how nutrients interact with soil. The different forms of nitrogen can be measured in soil. Plants and microbes will take up the inorganic forms quickly (NO3- or NH4+). There can be organic forms of nitrogen in soil as well. Scientists spend time measuring these forms of nitrogen all over the world in many kinds of soil. Before humans fertilized soil, soil nitrogen was considered to be low and most of it was in the plants and bacteria.

Additionally, soil pH is very important because it determines how available some nutrients are to plants. Soils at the LTER plots are around 7. Phosphorus is an important element for plants too. In order for P to be available for plants, soil pH needs to be in the range 6.0 and 7.5, otherwise phosphorus will attach to other molecules and form insoluble compounds. Other important nutrients can become too available and toxic in acidic soil or less available if the soil is too basic. This is why soil scientists study soil pH.

There are many examples from the BEST plots that can be used while teaching chemistry. Electronegativity and drawing Lewis structures is one example.

**ACTIVITIES OF THE SESSION**

See soil nutrients and pH protocol.

**ACTIVITIES OF THE SESSION**

1. See soil nutrients and pH for activities
2. Once the students have measured nutrients have them discuss the results. What were the concentrations of ammonium and nitrate.
3. Have the students brainstorm different ions in the soil.
4. How could they observe these ions?
5. Have the students draw the Lewis structure for them (Ca 2+, N2, NO3- and NH4+,PO4-3)
6. What are the valence states for nitrogen? Phosphorus?

**Resources**

**EXTENTIONS AND MODIFICATIONS**

**The soil of chemistry is really cool!**

**There lots of other BEST plot examples that can be used to teach chemistry. to Redox reactions and solubility are also important aspects of soil.**

Calcium can be leached under acidic conditions. This is an important aspect of soil weathering. Also, acid rain can leach calcium from soil. If you notice that your soil have effervescence, then your soil contains calcium.

**Cation exchange:**

Ca-soil +2NH4+ <-> (NH4+)2-soil +Ca 2+

3Ca(HCO3)2 + Al2-soil -> Ca3-soil +2Al(OH)3) + 6CO2

This is why we use KCl to extract nutrients. The potassium replaces the ions, which also replaces NH4+. Scientists can only measure nutrients in solution, so scientists need to get the NH4+ off of the soil.

**Anion Exchange**

**Phosphorus is especially interesting because it can bind to lots of different things in soil. It can bind to calcium, iron and organic matter. Phosphorus (in the form of phosphate) gets “stuck” to clay particles. This example below occurs in acid soils.**

-Al-OH (clay) +H2PO4- -> -Al-H2PO4 +OH-

**OR**

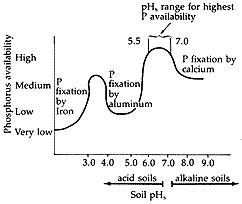
Al3+ +3H2PO4- -> Al(H2PO4)3 This is insoluble in water and unavailable to plants!

This is an example of the chemistry where phosphorus gets “stuck” to calcium. This occurs in basic soils.

3 Ca2++2PO4 3- -> Ca(PO4)2  !

2 CaCO3 +2PO43- -> Ca3(PO4)2 + 3CO2

This is insoluble in water and unavailable to plants.



Source: http://extension.missouri.edu/publications/DisplayPub.aspx?P=G9180

**Chemical reactions in soil**

**Redox reaction in soil**

4Fe2+ +O2 + 4H+ -> 4Fe3+ + 2H2O (Use this as a discussion of soil color- why is some soil rusty looking?)

2SO3 2- ->O2 + 2SO4 2-

Here is an important aspect of the nitrogen cycle where some microbes convert ammonium to nitrite and then others convert nitrite to nitrate. The microbes get energy from the reaction.

2 NH4+ + 3O2 -> 2 NO2- +2H2O + 4H+ + energy

2NO2- + O2 -> 2NO3- + energy