Soil has a Charge!

Soil Science Society of America

Type of Lesson
Hands-on

Materials Needed
- 6-volt lantern battery
- 2 lengths of copper wire with different colored insulation
- Clay (bentonite)

Time Required
15 minutes

NGSS Standards
- ESS2.A
- PS1.B
- PS3.D

How does soil keep fertilizers from leaching out of the plant root zone where they are needed?

Soils are composed of solid particles with spaces (pores) between them. The pores always contain some air and water. The solids can be minerals or organic (decomposed plant and animal remains). Soil particles are classified by size: sands (2.0 to 0.05 mm), silts (0.05 to 0.002 mm) and clays (<0.002 mm). Due to their small size, clays particles have thousands of times more surface area than sands – and clay surfaces have charges.

It may seem confusing, but in soil science, clay can refer to the particle size (<0.002 mm) or to a type of mineral. There are different kinds of clay minerals, which have varying amounts of negative surface charge. Organic matter also has a charge. These charges affect the ability of soil to hold and release plant nutrients. Plant nutrients are ions - atoms, compounds and molecules with a net electrical charge. Ions have negative charges and cations have positive charges. Water in soil always contains ions. These ions can freely move to and from the water and the charged soil surfaces in a process called ion exchange.

Both clay and organic matter typically have negative charges, though some might develop positive charges in strongly acidic soils. The total amount of cations a soil can adsorb (hold to its surface) is called the cation exchange capacity (CEC). The CEC is determined by the amount and type of clay minerals and the amount of organic matter.

It determines how many nutrients the soil can hold and how quickly nutrients move through the profile. A soil with low CEC (less clay and organic matter) is less fertile because it cannot hold many nutrients and is more likely to lose nutrients as water moves through the root zone (leaching). In low CEC soils, it is important to apply fertilizer in small doses to limit leaching which could potentially pollute groundwater.

Determine if soil has a positive or a negative charge.

1. Cut two lengths of copper wire about 8 inches long.

2. Attach one copper wire to the positive pole of the battery and attach the second copper wire to the negative pole (see photos). Be sure that the insulation is off the wire at the points of contact to the battery and in the clay slurry. (Any size battery will do, but a higher voltage battery works faster and better).

3. Place the ends of the wires in a flask or cup filled to the top with clay which has been mixed with water to the consistency of glue. Make sure you use the stickiest clay you can find.

4. After 10 minutes check to see whether the clay particles have moved to the wire attached to the positive or negative pole. Remember, opposite charges are attracted to each other.

Learn more about the set-up at: https://cdrdirt.com/soi-is-charged/

Discussion

These ions are commonly added from limestone, fertilizers and rain to garden and farm soils:

Cations	Cations	Anions
H^+ Hydrogen	Ca^{2+} Calcium	Cl^- Chloride
NH_4^+ Ammonium	Mg^{2+} Magnesium	NO_3^- Nitrate
K^+ Potassium	Mn^{2+} Manganese	SO_4^{2-} Sulfate

Based on the results of the above demonstration, put a check beside those plant nutrient ions in the list above that will attach to the exchange sites on the soil. These ions will not leach out of the soil or will do so only very slowly.