Lab Report

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Soil colloids tend to have a net negative charge for two reasons: surface area and pH levels. The higher the surface area, the more likely the soil is to have a negative charge. Also, the higher the pH level, the more negatively charged the soil will be.

Cation exchange is the process by which charged elements trade places with each other in the soil colloids. Cations are positively charged by definition (the opposite would be anions, which are negatively charged). The negatively charged soil colloids hold onto positively charged cations, but can be exchanged with other positively charged cations when they enter the solution. Plants release positively charged hydrogen from their roots (Brady & Weil, 2010), which often trade places with cations on the soil colloids, giving the plants nutrients. Below is an example formula:

(Drawing)

Soil pH is the measure of acidity or alkalinity in the soil. It is measured by logging the negative of active hydrogen ions in the soil. The equation for this measurement is (-log[H+]). The pH levels in soil are important to the fertility of the soil. Most plants thrive in pH levels between 5.5 and 7.0 (Soil). Within this range, many important plant nutrients are able to remain bonded with soil colloids such as calcium, magnesium and potassium. Plants with more access to nutrients that exist between 5.5 and 7.0 on the pH soil will have a better chance of growth.

Cation exchange capacities for the four different soil samples, based on two repetitions of the experiment yielded CECs ranging from 2.25 to 23 cmol/kg soil. The lowest was the Leetonia soil which had a CEC of 2.25 cmol/kg in Rep. 1 and 3.5 cmol/kg in Rep. 2. The highest was from the Gilpin soil with 23 cmol/kg in Rep. 1 and 22 cmol/kg in Rep. 2. Even though these soils have similar textures and makeup of sand, silt and clay, and are from the same region, their CECs are wildly different. The Hagerstown and Hublersburg soils are consistent with the CECs that would exist in the natural environment for this area. Their CECs range from 8.5 cmol/kg to 16.25 cmol/kg. It is the Leetonia and Gilpin soils that stand out. The Leetonioa could have such a lower CEC for a couple reasons. It could have been over-cultivated. When this happens, plants release H+ into the soil, trading places with other positively charged ions for nutrients, such as Potassium and Calcium. If plants are planted, harvested and re-planted without proper fertilization, the H+ cations saturate the soil in the area and leave no room for other, more nutritious cations.

A reason why the Giplin soil might have such a high CEC is possibly a higher concentration of organic material in the soil, or humus. This could have happened from plant matter that decomposed long ago or was deposited by a stream. Humus has even a higher surface area than clay and has a negative charge as well, which makes more space, or capacity, for the attachment of positively charged ions. The fertilization of soil may also change the CEC, or the introduction of pollutants from the surrounding environment. It is also possible that the soils with a lower CEC have higher concentrations of highly-charged cations like Al+3, which result in a lower negative charge in the soil. On the other hand, soils with higher concentrations of lower charged cations like Mg+2 have a higher CEC because the negative charge in the surrounding soil is more powerful. This can be just random chance in the soil composition or due to fertilization by farmers.

The pH of the soil samples were mostly in the range for fertile soil. The two methods of testing, the electrode and organic dye methods, gave similar results. Not surprisingly, the soil treated with lime was close to 7 on the pH scale and needed no other treatment. With the electrode, lime treated soil came to 6.92 but using the organic dye, it was an even 7. The soil treated with fertilizer and compost was the lowest in both tests. Using the electrode, soil treated with fertilizer was 4.35 on the pH scale and 5.67 using the buffer. Using the dye BTB, fertilized soil was 5.0 and with the CPR dye, it was 5.2. Composted soil was 4.25 using the electrode and with the buffer, it was 5.9. With the BTB dye, composted soil was 5.2 and with the CPR dye, it was 5.0. In all cases, the pH was slightly higher when using the organic dye. This is due to the more accurate nature of the electrode test, that measures the electricity's interaction with the H+ ions in the soil (Singer & Munns, 2006). The test using dye is quicker and used in the field, but less accurate because instead of measuring electrical interactions with H+ ions, it simply changes colors based on the pH of the solution it is in. Also in all cases, the soil treated with lime had a higher pH than the control and the fertilized and compost soil had a lower pH than the control.

The reason pH would be lower with compost and fertilizer rather than lime is first because lime is a strong base. This is why it is used to bring pH higher in soil. Second, compost and fertilizer are both used to add nutrients to soils so plants can use them. To do that, they often add positively charged ions that bond with the negatively charged soil colloids. The more positively charged ions that exist in the soil, the weaker the negative charge. The weaker the negative charge in the soil, the more acidic it is.

The soil management in this region seems to be handled well. The pH of the fertilized soil was very close to the control sample. This indicates that despite the fact that fertilizer makes soil more acidic, farmers in the area were still managing to keep the soil very close to the same pH as it is naturally. For example, electrode measurements of the pH of fertilized soil compared to control soil was only a difference of between 0.3 and 0.16 on the pH scale.

References

Brady, N., & Weil, R. (2010). Elements of the Nature and Properties of Soils (3rd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

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