**SOIL 4234 Laboratory #3**

**pH and Lime Requirement (15 points)**

Student

Lab

TA

**Objectives**

1. Define soil pH.
2. Explain the value of measuring soil pH in a 1:1 soil:water solution, 1:2 soil:water solution, and 0.01 *M* CaCl2 solution.
3. Explain how the Sikora buffer estimates the lime requirement of a soil.
4. Accurately measure soil pH values in a 1:1 soil:water solution, 1:2 soil:water solution, 0.01 *M* CaCl2 solution, and buffer solution.
5. Make a lime recommendation based on soil buffer pH.

**Introduction**

Soil pH is a measure of the acidity which is closely related to the concentration of hydrogen ions in the soil solution. Pure water dissociates, to a slight degree, into H+ and OH-. At 23oC the product of the concentrations of H+ and OH-, in moles per liter, is 10-14. Since the concentrations of both ions are equal, the concentration of H+ = 10-7, which is one ten millionth mole (10-7 g of H+) per liter of water. By definition, pH is the negative logarithm to base 10 of the H+ activity/concentration in moles per liter: pH = -log[H+], which at 23 oC is 7. When the [H+] exceeds [OH-] in a solution the pH is below 7, and it is acidic. Conversely, when [OH-] exceeds [H+], the pH exceeds 7, and the solution is basic.

In soil, the H+ and OH- concentration in the soil solution is in equilibrium with the H+ and OH- on exchange sites or in the solid phase. Generally, the acidity present in the soil solution, or active acidity, represents only a small portion of the total acidity in the soil, but is a good indicator of the mixture of cations present on the exchange sites. High levels of H+ in the soil solution (or low soil pH) normally indicates that a large portion of the cation exchange sites of the soil are saturated with acidic cations (H, Al). High soil pH, or low concentrations of H+ in the soil solution, indicates the bulk of the exchange sites are saturated with basic cations such as K+, Ca+2, and Mg+2.

Cations in the soil solution can displace H+ from exchange sites on soil particles and lower soil pH. Irrigation with saline water and or fertilizer additions can increase the solution H+ concentration and create a low pH. Sometimes soil pH is measured in a dilute salt solution such as 0.01 M CaCl2, rather than water, in hopes that the salt content of the CaCl2 solution will closely match the salt content of "normal" soil solution. Thus, the dilute CaCl2 solution displaces roughly as many H+ ions as the natural soil solution in the field. While this salt pH is not normally used for field crops, it is used for high value crops sensitive to low pH such as watermelons and cantaloupe.

**The Significance of Soil pH**

Soil pH is used as a method for diagnosing possible toxicity or nutrient deficiency problems in plants. Soil pH is simple to measure and is usually the first test that is done if nutrient problems are suspected. Soil pH may also indicate approximate base saturation level of the soil and relative degree of dissociation of H+ ions from cation exchange sites.

Knowledge of soil pH can tell a great deal about soils. A soil pH below 4 indicates the presence of free acids such as H2SO4, which can form from sulfides; at pH's between 4 and 5.5 direct injury to plant roots from H+ can occur, and toxic concentrations of Al and Mn may be present. The elements toxic at low pH and those which may be limiting at high pH generally reach their optimum level of availability at pH 6-7. Therefore, this pH range is considered optimum for many (but not all) of our agronomic crops. At pHs above 7, manganese, zinc, iron and copper may be too insoluble to meet plant needs. A pH from 7.8 to 8.2 normally indicates the accumulation of CaCO3 in the soil, and a pH greater than 8.5 usually indicates dominance of Na+ on the exchange sites.

In addition to having effects on plants and plant nutrition, soil pH also has important effects on chemical and biological processes that occur in the soil. Organisms responsible for decomposition of residue, nodulation of legumes, and nutrient transformations such as the oxidation of ammonium to nitrate have optimum pH's similar to plants. Thus maintaining soil pH in an optimum range for crop growth can enhance many other processes.

Activity or carry-over of herbicides can also be affected by soil pH. Many herbicides specify pH levels at which the compound can be used. The triazine family, which includes atrazine and cyanazine (Bladex), are most effective at high pH. Weed control activity can be lost when soil pH drops below 6. However, carry-over problems with these compounds can occur at high pH’s. Rotation of soybeans in fields treated with atrazine is not recommended at pHs above 7. Many other herbicides have label restrictions that prevent their use at high soil pH due to carry-over or crop injury.

**Liming soils to adjust pH.**

The aim in liming is to adjust a soil to a pH where most potentially toxic elements are rendered non-toxic and most essential elements are at an optimum level of availability. Hence, it is quite important to have a test that indicates the amount of lime required to raise a given acid soil to a selected pH level.

Measuring pH from Soil-Water pH (pH1:1 and pH1:2) and Soil-Salt pH (pHCaCl2)

A common method of measuring soil pH is performed by placing a glass electrode in a mixture of soil and deionized water.  Various modifications exist for determining soil pH.  The most common ratio used for soil-water pH is 1:1 soil:water.  Some laboratories measure pH in a 1:2 ratio of soil to deionized to improve the fluidity of the slurry; particularly for soils with high organic matter and clay concentrations that can absorb a significant volume of water.  Electrolyte solutions, such as 0.01 *M* CaCl2 or 1 *M* KCl, can be added to soil rather than deionized water with the resultant pH referred to as salt pH.  Use of electrolyte solutions avoids variable soil-water pH due to varying background salt levels in different soils and improves electrical conductivity in the electrical circuit for pH measurement.  Soil pH measurement in deionized water or 0.01 *M* CaCl2 in 1:1 and 1:2 soil:solution ratios are official methods adopted by the Association of Official Analytical Chemists.

Estimating Lime Requirements by using soil buffer pH

The amount of lime that must be added to a soil to change its pH is a function of the soil’s buffering capacity. Two soils with the same soil-water pH may not require the same amount of lime to raise their pH’s to identical values. This is because when we lime a soil we are not just neutralizing the acid in the soil solution that the pH meter measures (active acidity). We must also neutralize the acidity on the soil exchange sites (reserve acidity) which comprises most of the acid in soils. Therefore, when two soils require an identical pH change, the soil with the greatest CEC (buffering capacity) will require the most lime.

The Sikora Buffer is the most common buffer used to determine lime requirement of soils. The process of estimating lime requirement by the buffer pH is based on the ability of a soil to lower the pH of a carefully prepared buffer solution, a salt solution capable of resisting pH changes as acidity is added.

The Sikora Buffer with a pH of 7.50 ± 0.01 contains potassium chloride, acetic acid, MES (2-(N-morpholino) ethanesulfonic acid monohydrate), imidazole, triethanolamine, and sodium hydroxide. When the buffer is added to soil, cations in the buffer replace the reserve H+ on the exchange sites of the soil and the reserve H+ is knocked into solution where it can be measured with the pH meter as active H+. A large amount of reserve H+ on the exchange sites results in a large amount of H+ being displaced into solution thus causing the pH of the soil buffer suspension to drop. The lower the pH of the soil buffer suspension, the greater the amount of lime needed to change the pH of the soil. The soil buffer pH is not directly related to the soil-water pH but is directly related to reserve acidity, lime requirement, CEC, and soil buffering capacity. Thus, if two soils have the same soil-water pH but one soil has a lower soil buffer pH, this means it has more reserve acidity, a greater buffering capacity, a higher CEC and therefore a greater lime requirement than the soil with the higher soil buffer pH.

Lime recommendations in Oklahoma

Lime recommendations in Oklahoma are based on the OSU Extension Fact Sheet, PSS-2229 by Johnson and Zhang. In the lab exercise we will utilize this fact sheet to calculate a lime recommendation for an Oklahoma soil.

**Reference**

Sikora, F.J. 2006. A buffer that mimics the SMP buffer for determing lime requirement of soil. In Soil Sci. Soc. Am. J. 70: 474-486. SSSA, Madison, Wisconsin.

**Procedures**

**Soil pH by the Glass Electrode pH Meter**

These methods, most commonly used in soil testing laboratories, involve the use of a glass (indicating) electrode paired with a calomel (reference) electrode (or a combination electrode) and plugged into a commercial pH meter. With proper standardization of the meter using buffers of known pH values, the voltage generated between the two electrodes indicates the pH of the soil suspended in solution. The glass electrode develops changes in voltage in proportion to the logarithm of the changes in [H+] in the soil suspension.

The pH meters will be standardized by instructor before lab. Please do not try to re-standardize meters. If you have any questions or doubts about the operation of the pH meter, be sure to ask the instructor!

A. Measuring soil pH in a 1:1 soil:water solution, 1:2 soil:water solution, 0.01 *M* CaCl2 solution.

1:1 soil:water solution

1. Weigh 10 g of soil and put into a sample cup
2. Add 10 ml of deionized water to the soil.
3. Stir intermittently for 20 minutes.
4. Read pH on the standardized pH meter and record value on data sheet under Soil pH1:1.

**DO NOT DISCARD SAMPLE!!! YOU WILL NEED IT LATER FOR THE SIKORA BUFFER METHOD!!!**

1:2 soil:water solution

1. Weigh 10 g of soil and put into a sample cup
2. Add 20 ml of deionized water to the soil.
3. Stir intermittently for 20 minutes.
4. Read pH on the standardized pH meter and record value on data sheet under Soil pH1:2.

0.01 *M* CaCl2 solution

1. Weigh 10 g of soil and put into a sample cup
2. Add 10 ml of 0.01 *M* CaCl2 solution to the soil.
3. Stir intermittently for 20 minutes.
4. Read pH on the standardized pH meter and record value on data sheet under Soil pH CaCl2.

B. Measuring the Soil Lime Requirement by the Sikora Buffer Method.

1. Add 10 ml of the Sikora buffer solution to the soil samples saved from the 1:1 soil:water solution measurement.
2. Stir intermittently for 20 minutes.
3. Read the pH on the standardized pH meter and record value on data sheet under Soil-buffer pH.

**Results:**

**SAMPLE # : \_\_\_\_\_\_\_\_\_\_**

**Soil pH by the Glass Electrode pH Meter**

Reading 1 Reading 2 AVG.

Soil-water pH (pH1:1)

Soil-waterDilute Salt pH (pH1:2)

Soil-Dilute Salt pH (pHCaCl2)

Soil-Buffer pH (pHBuffer)

**Show calculations for averaging pH values.**

Using Table 2 in the OSU Extension Fact Sheet, PSS-2229 by Johnson and Zhang and the soil buffer pH, determine the lime required to raise the pH of your soil to 6.8. Note: This Table uses lime of ECCE = 100% (3 pts).

Reading 1 Reading 2 AVG.

Soil-Buffer pH (from above)

Lime recommended (Tons/acre)

***Show all calculations to receive full credit!***

**Data** (7 pts)

Please include all raw data and calculations.

**Questions**

1. (2 pt.) How does CEC affect reserve acidity, buffering capacity, and lime requirements of soils?
2. (4 pts.) Explain what is Buffer Index and give an example of how it is used. For example, a clay and a sand soil with same pH value but different buffer indexes?
3. (2 pts.) Table 2 in the OSU Extension Fact Sheet, PSS-2229 by Johnson and Zhang is based on lime with an effective calcium carbonate equivalent (ECCE) of 100%. Complete the table below which uses lime that does not have an ECCE of 100% to adjust the pH to 6.4.

|  |  |  |
| --- | --- | --- |
|  | ECCE (%) | |
| Buffer pH | 40 % | 80 % |
| 6.8 |  |  |
| 6.2 |  |  |