



TEST METHODS MANUAL

Laboratory Services Division
Bureau of Soils and Water Management
Department of Agriculture

TM-LSD-04-01

SECTION : SOIL CHEMISTRY

Issue No.: 3

Effective date: April 15, 2024

SUBJECT : **SOIL pH**

Revision No.: 1

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SCOPE

This method presents the common measurement of soil pH in a 1:1 mixture of soil to deionized water along with modifications with electrolyte solutions using a pH meter.

The pH-H₂O method measures active acidity and is used for fertilizer recommendation and for routine analysis.

The pH in one molar potassium chloride (1M KCl) is used to measure reaction in highly weathered tropical soils.

The pH in one-one hundredth molar calcium chloride (0.01 M CaCl₂) method is applied for soil characterization, soil classification, and soil taxonomy purposes. The pH in 0.01 M CaCl₂ is somewhat, but not entirely invariable with naturally changing salt concentration in soils.

PRINCIPLE

A measured quantity of soil is shaken with a convenient volume of water or an electrolyte solution under consistent conditions. Soil pH is determined with an hydrogen ion (H⁺) ion-selective glass electrode (referenced with a standard calomel electrode) inserted into a soil mixture that simulates the soil solution. The difference between the H⁺ ion activities in the soil solution and the glass electrode gives rise to an electrometric potential difference that is related to the soil solution pH, or the active acidity.

It is determined by the concentration of hydrogen ions. It is measured using the formula of the negative logarithmic scale of the hydrogen ion concentration, [H⁺], pH = -log[H⁺]. The soil pH value is either an acidic solution (less than 7) or an alkaline solution (greater than 7). This would imply that as the hydrogen ion concentration increases, the pH value decreases, and vice versa with alkaline soil solution.

Soil pH is influenced by both acid and base-forming cations (positively charged dissolved ions) in the soil. Common acid-forming cations are hydrogen (H⁺), aluminum (Al³⁺), and iron (Fe²⁺ or Fe³⁺), whereas common base-forming cations include calcium (Ca²⁺), magnesium (Mg²⁺), potassium (K⁺) and sodium (Na⁺).


Nutrient availability is characterized and approximately calculated using soil pH. Hydronium ions take up space in the soil surface which affects the availability of some elements. At higher pH, potassium, sulfur, calcium, and magnesium are readily available. On the other hand, soil micronutrients, such as zinc, copper, boron, manganese, and molybdenum, are readily available at lower pH. Furthermore, specific pH values can predict the dominant cations on soil cation exchangers at the time of soil sampling and analysis. Also, these specific pH values can predict the presence of mineral acids (pH 2-3), exchangeable Al³⁺ at pH 4-5, and presence of carbonates (pH 7.6-8.3) which can be classified as calcareous soil.

In determining the pH value of soils, analysts can identify what affects the plants. All plants can be affected by the extremes of pH depending on their tolerance of acidity and alkalinity. Some plants can grow in a wide pH range, while others are highly sensitive to small variations of acidity or alkalinity. Microbial activity in the soil can also be affected by soil pH. Furthermore, various species of earthworms and nitrifying bacteria disappear when there is an occurrence of extreme acidity or alkalinity. The changes in the availability of nutrients can have some effects on plant growth attributed to acid soils. Soil pH affects the availability of nutrients and how it reacts with each other. At a low pH, beneficial elements, such as molybdenum (Mo), phosphorus (P), magnesium (Mg) and calcium (Ca) become less


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available to plants. Other elements, like aluminum (Al), manganese (Mn) and iron (Fe) may reach levels that are toxic to plants. Thus, knowledge of the soil pH and associated aluminum toxicity is vital before planning to sow crops or pastures. Also, alkaline soil causes zinc and cobalt deficiencies that lead to stunted plants, poor growth, and reduced yields in some crops and pastures.

The pH of soil changes over time. Historical data of soil will assist in monitoring the changes in the soil. Thus, continuous assessment of soil would prevent any trends from occurring.

TEST PRECAUTIONS

The pH values are dependent on temperature. It should be measured at a constant temperature. If a precision greater than 0.1 pH unit is desired, the temperature of the standard solutions, the glass electrode, and the test solution must be within 2°C of one another.

In soil pH measurement, electrodes may be placed in the soil slurry. Allow adequate time for pH to reach a stable reading. Differences in pH will occur with the electrode placed in soil slurry versus the supernatant after the soil has settled. The differences are more pronounced with soil pH in water compared to electrolytes solutions. To avoid this variability in pH, it is important to stir the soil slurry right before measurement. With sandy soils, the settling time of soil particles is rapid and continuous stirring during measurement is recommended.

Keep electrodes wet by returning them to the storage solution whenever the pH meter is not in use. Recommended solutions for short-term storage of electrodes vary with the type of electrode and manufacturer.

Clean the glass electrode periodically, if necessary, by soaking it in a solution of a mild detergent and wiping it with a piece of tissue paper, to remove the film of soil that adheres to the electrode surface. A film of CaCO_3 that sometimes forms on the surface of the glass electrode during measurement of pH of calcareous soils may be removed by dipping the electrode for a few seconds in dilute HCl and rinsing it with water.

Glass electrodes have a short life span when measuring the pH of sandy soils. The sand particles are abrasive to the glass resulting in electrode breakage or malfunction. Replace electrodes when pH calibration buffers exceed ± 0.05 pH units, even after recalibration, or when pH of quality control samples consistently exceeded the expected error.

EQUIPMENT

- pH meter equipped with glass and reference electrode, or combination electrode
- Analytical Balance, precision of at least 0.001g
- Mechanical Reciprocating shaker

LABORATORY WARE

- Pipet or Bottle Top dispenser, 10 mL
- Plastic Beakers, 500 mL or 1000 mL
- Wash Bottles
- Centrifuge tubes or Polyethylene container, 50 mL or 100 mL capacity

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CHEMICALS AND REAGENTS

- NIST Traceable standard buffer solutions of pH 4.0, pH 7.0, and pH 10.0
- Deionized water
- Calcium chloride, 0.01 M. Dissolve 1.47 g of $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ in one-liter distilled water
- Calcium chloride, 0.02 M. Dissolve 2.94 g of $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ in one-liter distilled water
- KCl solution, 1M. Dissolve 74.55 g dry KCl in distilled water and make up to 1 L

HEALTH AND SAFETY

Wear proper personal protective equipment. Use a laboratory coat, closed shoes, gas mask or dust masks and appropriate gloves when performing chemical analysis. **Limited Preview**

For Laboratory Use: always check the SDS and COA for each delivered chemical to confirm if it is compliant with the specifications. **For full access, kindly fill out the Document Request Form**

PROCEDURE

Google form link:

<https://forms.gle/RbCgCdA54prTS6oN7>

Calibration of the pH meter

- Calibrate the pH meter using pH Buffers 7, 4, 10. Note that it can be a 2-point or a 3-point calibration.
- The slope value is based on the specified performance requirement stated on the equipment user's manual. If the slope is not within the accepted percent slope of the equipment, recalibrate again.
Note: Refer to EM-LSD-06-04 pH meter for monitoring of millivolts.
- Read the standard pH buffer 7 for initial calibration. **Thank you!** If the reading of standard pH 7 is within 7.00 ± 0.1 , then continue to sample analysis. Otherwise, repeat calibration until it is within the range.

A. pH in Water (H_2O 1:1) (Thomas, 1996)

- Weigh out 10 g of air-dry soil in a 50- or 100-mL container tube.
- Add 10 mL of deionized water to the soil in the container tube and place a stopper
- Using a mechanical reciprocating shaker, shake for 10 minutes at 250 rpm.
- Stand for 10 minutes.
- Read the pH of samples and record. Rinse the probe between samples and remove excess water using lint-free wipes.
Note: must be placed in the soil slurry part and allow adequate time for pH to reach a stable reading.
- Read standard pH 7 buffer every 10th sample for intermediate standard check.
- Rinse the electrodes thoroughly and immerse in the filling solution when not in use.

B. pH in 0.01 M and 0.02 M CaCl_2 (Thomas, 1996)

If pH determination in water is also required, use 0.02 M CaCl_2 (CaCl_2 1:2)

- Add 20 mL of 0.02 M $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ to the soil suspension used in determining pH in water and place a stopper.
- Using a mechanical reciprocating shaker, shake for 10 minutes at 250 rpm.
- Stand for 10 minutes.

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