UNIVERSITY OF
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IFAS EXTENSION

Soil pH and Electrical Conductivity: A CountyExtension Soil Laboratory Manual [1]

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PURPOSE

This manual has been designed as a reference source for county extension laboratories offering soil pH and/or electrical conductivity tests to their clients. This manual, if followed, will assist county faculty in assuring that these laboratory measurements are done correctly with high quality assurance.

SOIL pH AND ITS USES

Soil pH measurement is useful because it is a predictor of various chemical activities within the soil. As such, it is also a useful tool in making management decisions concerning the type of plants suitable for a location, the possible need to modify soil pH (either up or down), and a rough indicator of the plant availability of nutrients in the soil.

Aluminum

Aluminum in the soil can adversely affect plants if aluminum occurs in certain forms and its activity is elevated sufficiently. As the activity of aluminum increases, the soil becomes more acidic and soil pH decreases. If the pH is low enough and aluminum is present in sufficient quantity, plants may be stunted or lost due to aluminum toxicity. In most Florida sandy soils, there is danger of aluminum toxicity when soil pH is below 5.0.

The occurrence of aluminum toxicity (at acidic pHs) decreases somewhat as one travels from the Florida panhandle and down the peninsula. The reason for this apparent change is found in changes in the soil constituents. Aluminum levels tend to decrease and the aluminum is found in different minerals in the soil as one travels south in Florida.

Organic soils have low total aluminum. Low soil pH in these soils does not pose a threat from aluminum toxicity in Florida.

Nitrogen Fixing Microbes

Legume plants have a helpful relationship with selected soil microbes. These microbes convert nitrogen gas from the atmosphere to forms useful to the plant for growth and improved yield. In turn, the microbes are supplied nutrients and carbohydrates from the plant. This mutual, beneficial existence is termed **symbiosis**. Agronomic examples of this symbiotic relationship are alfalfa, peanut, and soybean.

Soil pH directly affects the activity of these microbes. Research, conducted in the absence of aluminum toxicity, has shown that once the soil pH has decreased to 4.7 or lower, the ability of the microbes to convert nitrogen is greatly reduced. If aluminum is present, then both the microbial

symbiotic activity and the normal metabolism of the plant are adversely affected.

Solubility of Plant Nutrients

Soil pH directly affects the solubility of many of the nutrients in the soil needed for proper plant growth and development. These chemical reactions are complex and have often been generalized with charts that oversimplify chemical conditions in specific soils. One should be careful in using these pH-nutrient charts when dealing with soils in Florida. They may be misleading.

As soil pH decreases, nutrients, such as phosphorus, usually decrease in plant availability because of precipitate reactions with iron and aluminum. However, plants can affect their micro-environment and are often found to grow well over a range of soil pH. This range of successful growth is often as great as 1 to 2 pH units. In general, many plants will do well in a soil pH range of 5.5 to 7.5. Specific plants, such as azalea or pine seedlings, actually require low soil pH. Such plants are often **iron inefficient**, meaning that they require low soil pH to aid in the uptake of iron from the soil.

As soil pH increases above 6.5, manganese, a micronutrient, may become limiting to plant growth. Phosphorus and micronutrients such as copper and zinc also decrease in their plant availability at high pH. Soils composed of limestone (such as those in the Dade County area) have a high native soil pH of about 8.3. Plants grow in these high pH soils, but nutrient deficiencies are common.

Optimum pH Ranges for Plants

As stated above, most plants do well over a range of soil pH values. This point bears repeating because the best management of soil pH is often to do nothing. Because many plants directly modify the chemical environment around their roots, nutrient limitations are not found, plant production is not adversely affected, and visual stress symptoms are not observed.

The University of Florida, IFAS, Extension Soil Testing Laboratory (ESTL) uses the IFAS Standardized Fertilization Recommendation System. This system contains all of the IFAS approved fertilizer and liming recommendations (Hanlon et al., 1990). Specific pH values are cited in this system as **target pHs**. A target pH is a soil pH, within the optimum pH range, that is used for the calculation of lime rates. A target pH is usually selected such that the adverse effects of aluminum toxicity are avoided, and so that nutrient availability for that crop will be adequate. A target pH is not the only pH at which the crop will do well.

Liming of Soils

If the soil pH is greater than 0.2 units below the target pH, the ESTL will complete an additional test, the Adams-Evans Buffer. This test has been specifically designed for the sandy soils found in the southern United States. Furthermore, current lime recommendations have been calibrated for Florida conditions using both the soil pH and the Adams-Evans Buffer.

Table 1. Lime requirement to reach a target pH of 6.0 or 6.5 for selected soils with soil pH = 5.7.

| Sample | Soil pH | Lime Requirement | | | |
| | | Target pH = 6.0 | | Target pH = 6.5 | |
		$\frac{lb}{acre}$	$\frac{lb}{1,000 \text{ sq ft}}$	$\frac{lb}{acre}$	$\frac{lb}{1,000 \text{ sq ft}}$
Alachua	5.7	1000	23.0	2600	59.7
Columbia	5.7	500	11.5	1000	23.0
Jackson	5.7	600	13.8	1500	34.4
Jackson	5.7	800	18.4	2100	48.2
Okaloosa	5.7	600	13.8	1500	34.4
Polk	5.7	600	13.8	1500	34.4
Polk	5.7	800	18.4	2100	48.2
Putnam	5.7	600	13.8	1500	34.4

Soil pH is a measure of the active acidity, that portion of the hydrogen ions that is active in the soil solution. Soil pH does not measure the **reserve acidity**. Reserve acidity is that portion of hydrogen and other acid-contributing ions that are sorbed on soil particles. Usually, the reserve acidity is much greater than the active acidity. The Adams-Evans test is designed to measure this reserve acidity. Together, the target pH, the soil pH, and the Adams-Evans test can be used to determine the amount of lime required to adjust the soil pH from its current reading to the target pH.

To see the effect of reserve acidity on lime recommendations, the data in Table 1 have been compiled. Soil samples from the indicated counties were all selected to have the same soil pH of 5.7. However, the amount of lime in pounds/acre or pounds per 1,000 sq ft to raise the soil pH to a target pH of 6.0 (columns 3 and 4) or to a target pH of 6.5 (columns 5 and 6) varies widely.

Unfortunately, the Adams-Evans test is rather complex and contains chemicals that must be handled and disposed of as hazardous waste. For this reason, county Extension laboratories should not offer the Adams-Evans test. However, local knowledge of the county and its soils can help considerably with local lime recommendations. It is recommended that liming recommendations made at the county laboratory be verified by submitting a small percentage (e.g., 5%) of soil samples to the ESTL. Comparison of the local recommendations with those from the ESTL will allow county extension faculty to calibrate their recommendations.

Acidifying Soil

In some situations, it may be desirable to acidify the soil, that is, to lower soil pH. If the high soil pH is a natural condition, there is little that can be done to lower soil pH permanently. Treatment with sulfur will lower the pH for a few weeks, but the pH will eventually increase.

In landscaping, it is often better to select plants which are adapted to the natural soil pH range, rather than to use plants which will need constant soil pH maintenance and usually look unhealthy even after this extra effort.

In situations where the high soil pH condition was created by human activity, for instance overliming, it is often feasible to lower the soil pH with one or two applications of sulfur. In such cases, the amount of overliming is relatively small, say 1 ton/acre (46 lb/1000 sq ft) and can be treated successfully. In naturally occurring, high pH soils, the effective lime equivalent will usually be over 100 tons/acre.

Unfortunately, there is no soil test available to assist in determining the amounts of sulfur (S) needed to reduce soil pH. If plants are actively growing, agricultural sulfur treatment should be restricted to a maximum of 300 lb S/acre (7 lb S/1,000 sq ft). Damage may still occur at this rate if the S is allowed to remain in contact with the foliage.

Multiple treatments during the growing season should be done with caution; that is, allowing enough time (usually about 1 month) for the previous S treatment to react with the soil. Sulfur added to the soil must undergo oxidation by soil microbes resulting in the production of hydrogen ions and sulfate. Since microbial action controls the effectiveness of the treatment, warm moist soil conditions are preferable to dry or cool conditions. Treatment of the soil with gypsum, which is calcium sulfate, will not change soil pH because gypsum does not contribute any acidity to the soil. It is a pH-neutral salt.

pH ELECTRODES

Figure 1 represents a drawing of the pH electrode, often called a glass electrode. The electrode and its reference electrode (Figure 2) may be combined into a single **combination electrode**. However, for ease of understanding, this discussion will deal with separate electrodes. All electrode parts are similar, whether they are used as two separate electrodes or as a single combination electrode.

The glass ball at the end of the pH electrode is composed of a special glass which has specific surface properties. The ball should not be touched nor allowed to dry out. Inspection of this part should include insuring that the ball has not been cracked, that it is full of solution, and that there is a thin wire extending into the upper portion of the ball within the electrode.

If the electrode has been inverted, the ball may not contain any solution. Gently tapping the electrode side with one's fingers while holding it vertical with the ball down is usually enough to displace the entrapped air with solution.
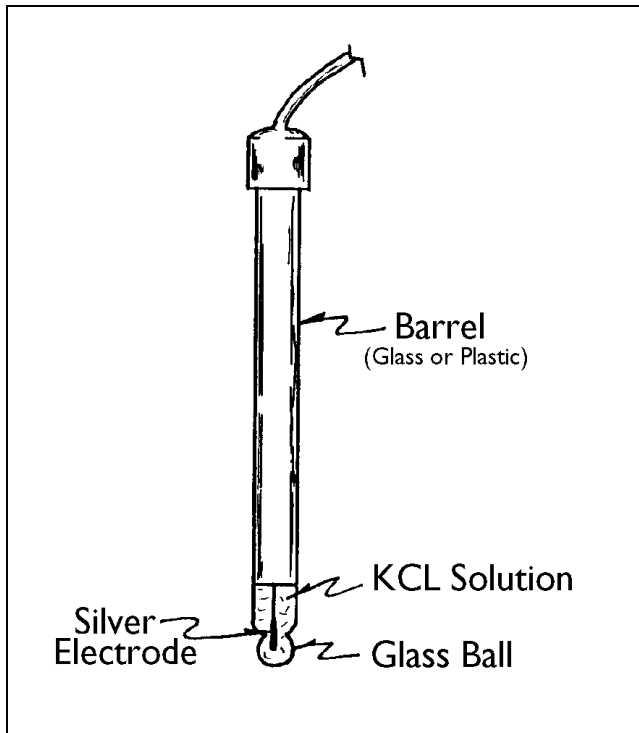
Figure 1. pH Electrode

Most manufacturers include instructions for maintaining (rejuvenating) the electrode if the ball has been allowed to dry out. Rejuvenation often calls for strong acids which present a personal safety hazard. County faculty may wish to replace electrodes rather than attempting rejuvenation.

Inspection of the electrode wire should not reveal any loose connections or breaks in the insulation. There are no serviceable parts on the pH electrode.

REFERENCE ELECTRODE

The reference electrode, also known as a calomel electrode, is shown in Figure 2. The electrode contains a fibrous or ceramic chip which allows the internal solution to slowly flow out from the body of the electrode into the external solution of the sample which is being measured. This leaking results in a completed electrical circuit. Inspection should include checking that the chip is in place and is relatively clean of debris from past use. Often the chip will be white or light gray in color, indicating that it is still functioning. If the chip is a different (darker) color, the electrode may not function properly. Use of a small amount of abrasion may restore the chip, but too much abrasion may damage the electrode.

Lastly, the barrel of the electrode often contains a filler port near the top of the electrode. Most manufacturers recommend that the covering be removed from this port so that pressures do not develop within the operating electrode. The solution, often a concentrated solution of potassium chloride (see specifications for your specific electrode), should be kept within 1 inch of the filler port. This level is sufficient to insure that the internal solution level is higher than the sample solution being analyzed. This difference permits flow out from the electrode through the chip.

A relatively new type of electrode is constructed with an internal fluid which is a gel. This type of electrode does not contain a filler port because it can not be serviced by the user.
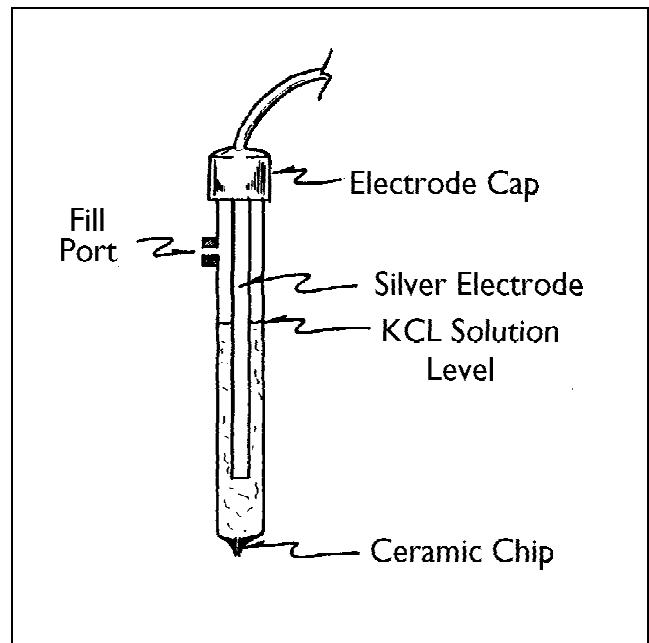

Figure 2. Calomel Electrode

pH METER

The pH meter is a sensitive electronic device, often designed with printed circuits making it quite reliable. However, improper handling (bumps, hot dash-board storage, or solution spills) can damage the meter. The meter is designed to measure changes of millivolts between the reference and pH electrodes. To understand the sensitivity needed to measure millivolts, human neck pains are often induced by 7 to 20 millivolts.

Most problems associated with reading pH usually originate with faulty electrodes. Additionally, if the

meter contains batteries, they should be checked before each use. Low or inadequate power supply will result in inaccurate pH readings.

In any case, unless the instrument completely fails, it will always give a pH reading whether it is functioning correctly or not! It is the responsibility of the operator to detect problems and to report accurate pH results.

ELECTRICAL CONDUCTIVITY AND ITS USES

The Electrical Conductivity (EC) of a solution is a measure of the ability of the solution to conduct electricity. The EC is reported in either millimhos per centimeter or the equivalent deciSiemens per meter. When ions (salts) are present, the EC of the solution increases. If no salts are present, then the EC is low indicating that the solution does not conduct electricity well.

The EC indicates the presence or absence of salts, but does not indicate which salts might be present. For example, the EC of a soil sample might be considered relatively high. No indication from the EC test is available to determine if this condition was from irrigation with salty water or if the field had been recently fertilized and the elevated EC is from the soluble fertilizer salts. To determine the source of the salts in a sample, further chemical tests must be performed.

Soluble Salts vs. EC

Prior to 1989, the ESTL reported Soluble Salts values. Soluble salts is an older term and is derived from EC measurements. Unfortunately, there are a number of assumptions which have to be made before soluble salts can be calculated. Conversion factors (EC to soluble salts) were different across the United States, ranging from 600 to 700. Florida used a conversion factor of 700.

These assumptions, and their introduced errors, are avoided by reporting the actual EC measurement. The EC can also be directly used in the body of literature which is continuously growing concerning plant productivity under the effects of salinity. The older term soluble salts should be avoided by county Extension laboratories.

Interpretation of Electrical Conductivity of Irrigation Water

Frequent use of irrigation water will directly influence the salts in the soil profile. Salts are influenced by factors such as rainfall content and timing, internal soil drainage, and irrigation practices. Usually, rainfall contains low amounts of salts and acts to dilute salts that are present in the soil. If the rainfall is of sufficient volume or duration, and the soil has internal drainage, the added rainfall is enough to leach salts from the soil. During drying conditions, water is lost from the soil due to evaporation, and salts are effectively concentrated. If irrigation water contains appreciable salts, then intensive management is required to produce healthy plants. Therefore, EC measurement of the irrigation water source is an excellent management decision. Table 2 has been developed to assist in making a decision to use a water source.

Table 2. Classification of irrigation water by electrical conductivity.

Class of Water	Specific Conductance dS/m
Excellent	<0.25
Good	0.25 to 0.75
Permissible	0.76 to 2.00
Doubtful	2.00 to 3.00
Unsuitable	>3.00

Interpretation of Electrical Conductivity of Soils

In actuality, the interpretation of EC of a soil or media must be made considering the plant(s) to be grown. The EC of the soil has little direct detrimental effect on sandy mineral soils or on media. However, EC directly affects plants growing in the soil or media. The impact of EC on plants is also directly affected by water management.

Salt Index Use and Calculation

As EC increases, more attention to water management is needed to prevent salinity from adversely affecting plants. The Extension Soil Testing Laboratory uses a 2:1 solution:soil ratio with which to determine EC. Many states use a saturated paste extract. This saturated paste method is more time consuming than the 2:1 extraction, and results in inadequate amounts of solution in Florida's sandy

soils. The conversion from the 2:1 extraction result to the saturated paste result, termed salt index, is easy and accurate.

$$EC \text{ (salt index)} = EC \text{ (2:1)} \times 8.$$

In general, when the soil EC (2:1, water:soil) exceeds 0.25 dS/m (or 0.25 x 8 = 2.0 dS/m salt index), many plants experience stress due to salts. Other plants (e.g., bermudagrass) are quite tolerant to salts. Due to this species-dependent effect of EC, a listing of the effects of increasing EC on selected plants has been compiled (Hanlon et al., 1993).

EC PROBE AND METER

There are a wide variety of EC probes and meters marketed. Those instruments using probes that are placed in the soil or media *in situ* (directly in the soil without taking a sample) are not considered in the following discussion. Since EC is a measurement of the conductivity of the soil solution, the measurement should be made under a controlled mixture of solution to soil (2:1). These conditions usually do not exist when direct reading instruments are used.

Electrical Conductivity Probe

The probe consists of a tube, usually of plastic, into which electrodes have been installed. Two common electrode arrangements are: 1) two plates; or 2) a rod located concentrically in a ring. In either case, the electrodes are held a specific distance apart. The gap between the electrodes is filled with the water sample or filtered solution from a soil sample, either by filling a reservoir or by placing the probe in the solution.

When the probe is immersed in the solution, ions contained in the solution will permit electrical flow from one electrode to another. If a large number of ions are present (salty conditions), then the EC of the sample will be higher than a sample with low number of ions (low salts).

Some older instruments require that a mixture of soil and solution be packed into the electrode receptacle. While readings from these older instruments may be adequate, accurate results are harder to obtain because readings are affected by the sample packing method.

Inspection of the probe should include insuring that the probe is clean and free of debris, and that all electrical connections are in place. Some probes may experience a buildup of corrosion on the electrodes with time. Indication of corrosion, if not directly visible, is indicated by the constant need to reset the instrument because of drifting, often in one direction as corrosion progresses.

Electrical Conductivity Meter

Meters for EC are extremely reliable. Meters from the 1950s which use a "cat's eye" tube are still in use. Newer meters using digital displays are often susceptible to failure of one or more segments of the digital display, usually related to corrosion within the instrument.

As with failures associated with pH meters, EC meters will always provide an EC, unless the problem results in total instrument failure. It falls upon the operator to insure that the reported EC is an accurate measurement of the conductivity of the sample.

LABORATORY PROCEDURES

The following procedures are used at the ESTL and are based on good laboratory procedures with sufficient quality control measures to insure that pH and EC readings are accurate and reliable. While equipment may vary among County Extension Laboratories, procedures should be developed that directly parallel those used by the ESTL.

I. Soil Scooping Technique

The ESTL uses a scoop (that is, a volume measurement) for both pH and EC determinations. The scoop is a plastic and metal device which may be obtained from a commercial manufacturer (e.g., Custom Laboratories, Orange City, FL). Alternately, the scoop may be constructed from locally available materials, such as measuring spoons or coffee scoops. The intent is to use a consistent volume of soil and water.

The soil scooping technique requires practice, despite its unsophisticated appearance. The technique depends upon uniform actions by the technician from sample to sample to produce consistent packing of soil into the scoop. This consistency can be directly measured by repeatedly scooping the same soil and weighing each scoop. Weights should be uniform within each scoop (volume) and soil-sample combination. Weights will

vary from soil to soil, especially when there is a noticeable difference in soil texture.

A. Sample Handling and Preparation

The sample should be air-dried and passed through a 2-mm sieve before scooping.

B. Procedure

1. Dip the scoop into the center of the soil sample and fill the scoop with a twisting motion so that extra soil is mounded above the rim of the scoop. Do not press the scoop or force the soil against the side of the container (Jones, 1980).

2. Strike the handle near the scoop three times with a plastic rod to settle soil particles.

3. Level the scoop with the plastic rod. Strike off all excess soil above the rim of the scoop in a single stroke so that the soil is not compacted into the scoop.

II. Estimation of Soil Texture

Knowledge of soil texture is useful in the recommendation of lime. Local soil conditions may be quite uniform so that little differences may be found throughout the county. However, such uniformity is expected to be rare in most counties. After the soil has been air-dried and sieved, a small amount of dry soil should be moistened and rubbed between the forefinger and thumb. An estimation of the texture is made by comparing the "feel" of the sample to that of a set of soil samples of known texture (Table 3).

III. Soil pH (2:1 V/V)

This procedure uses a 20-cc (~25 g) soil scoop and 40 mL of pure water to obtain a 2:1 water-to-soil ratio. Most problems with this procedure are associated with the glass or calomel electrodes. However, sample pH may also be affected by contaminated water, by microbial activity if samples are allowed to sit for several hours before determining pH, or by improper scooping techniques.

A. Standard Solutions

Obtain commercial standard solutions of pH 4.00, 7.00, and 10.00.

B. Sample Handling and Preparation

The soil sample should be air-dried and passed through a 2-mm sieve. Irrigation water samples require no preparation.

C. Procedure

1. One scoop (see Soil Scooping Technique) of soil to a 3-oz plastic cup using a 20-cc (~25-g) scoop.

2. Add 40 mL of pure water to each cup using an automatic pipette or suitable volumetric container. Stir with a glass rod and let the sample stand for 30 min.

3. Standardize the pH meter (see following section, pH Meter).

4. Stir the sample again immediately before measuring the soil pH. Do not place the electrode(s) directly in the sand layer at the bottom of the container. The electrodes should be positioned in the solution just above the sand layer.

5. Record pH to the nearest 0.1 pH unit (suggested format of XX.X).

IV. Electrical Conductivity

This test, often called "Soluble Salts," requires that 20 cc (~25 g) of soil be mixed with 40 mL of pure water, resulting in a water:soil ratio of 2:1. The 4-hr equilibration period provides time for some slowly-soluble constituents to approach solution equilibrium. Little error results from much longer equilibration times, but shorter time periods might introduce inconsistent results for some samples.

A. Standards

A solution of 0.005 N KCl has an electrical conductivity of 720 ± 1 dS/m (mmho/cm) at 25°C. Use a commercially prepared solution as the reference solution.

Table 3. Soil texture can be determined by the feel of the soil sample.

Textural Name	Description
Sand	Loose and single-grained with a gritty feeling when moistened. Not sticky and will not form a ribbon when pressed between the thumb and index finger. Includes fine sand, loamy sand, and loamy fine sand.
Sandy Loam	Contains sufficient silt and clay to give coherence to the moistened soil. Feels gritty and slightly sticky. Will not form a ribbon. Includes fine sandy loams.
Clay Loam	Forms short ribbons less than 3 cm long. Forms a hard, firm aggregate when dry. Includes sandy clay loams and silty clay loams.
Clay	Extremely sticky and plastic when moist. Easily firms ribbons longer than 3 cm. Includes sandy clays.
Organic/Mineral	Term used in place of a textural class Soil Intergrade for soils that contain up to 50% organic matter by volume.
Organic	Term used for soils that are predominately organic but which may contain up to 50% mineral matter by volume.

B. Sample Handling and Preparation

The soil sample should be air-dried and passed through a 2-mm sieve. Irrigation water samples require no preparation.

C. Procedure

1. Place 20 cc (~25 g) of soil in a plastic 3-oz cup.

2. Add 40 mL of pure water, stir, and allow to stand for 4 h.

3. Without stirring the sample, filter the solution through a Whatman No. 41 (11 cm) paper and collect the extract in a funnel tube or other suitable container. The intent is to remove the soil and other debris from the solution.

4. Standardize the conductivity meter (see the following section on the Conductivity Meter).

5. Move the probe up and down in the solution several times to dislodge any bubbles on the electrode surfaces. Measure the electrical conductivity of the extract contained in the funnel tube.

6. Rinse the interior and exterior of the probe with pure water between samples. Remove any excess water from the exterior of the probe by blotting with a tissue.

7. Record all meter readings as displayed. Note that some meters use a floating-point display while others use a reading which depends upon a switch setting.

V. pH Meter

Instructions for the proper use of a pH meter, including electrode care and instrument-specific settings, are given in this subsection. While instrument settings may vary among meters, daily operation of pH meters is relatively standard. Most problems with pH instruments originate within the electrode(s) or in the electrical connections to the instrument. Prevention of early electrode deterioration is best accomplished by following the information in sections B and C that follow. Use of only one standard buffer solution is not adequate for proper calibration. Do not reuse a buffer solution which has been left out overnight or has been used to "store" electrode(s). It is advisable to maintain a supply of a reference soil sample (See Appendix for more information) to be used as a check sample with every set of samples. Early detection of problems is the best method of avoiding inaccurate results.

A. Calibration of Electrode(s)

1. Rinse electrode(s) with pure water and blot dry with a tissue or clean paper towel.

2. Using commercially prepared buffer solutions of pH 4.00, 7.00, and 10.0, pour approximately 30 mL into labeled, 3-oz.

plastic cups. Do not reuse buffer solutions in which electrode(s) have been immersed for daily storage.

3. Set the meter to operate in the "pH" mode.

4. Place the electrode(s) into new buffer solution (pH 7.00) and allow the electrode(s) to equilibrate. A stable reading should be obtained within about 30 seconds. Readings which are not stable after 1 minute indicate that the electrode(s) may be malfunctioning.

5. Using the "Calibration" (often labelled "Standard") knob, adjust the pH-meter display to read 7.00. Do not move (or press) either the "Temperature" or "Slope" adjustments at this time.

6. Place the meter in the "Standby" mode. Some meters do not have a standby mode.

7. Rinse the electrode(s) into a waste cup with pure water and blot dry as above.

8. Place the electrode(s) in new buffer solution (pH 4.00) and allow the electrode(s) to equilibrate with the buffer solution.

9. Set the meter to operate in the "pH" mode.

10. Using the "Temperature" knob (sometimes labelled "Slope"), adjust the pH-meter display to read 4.00. Do not readjust the "Calibration" setting at this time.

11. Repeat Steps 6 through 9 using the pH 10.0 buffer solution. No settings should be changed as the pH 10.0 buffer is being read.

12. Repeat Steps 3 through 11 until readings of 7.00, 4.00, and 10.0 are obtained without adjusting the instrument. These standards should be set ±0.05.

13. Using a reference soil sample (see Appendix), read the pH and determine if the pH reading agrees with the "known" reading of the reference soil. Use of a reference soil sample, a soil that can be analyzed with every sample set, is strongly recommended. Use of a reference soil is an excellent quality assurance measure and verifies that the electrode(s)/meter are functioning correctly in a soil solution and not just in standard buffers. The reference soil sample should be read once about 20 samples. If the reading drifts by more than ±0.2, then restandardize the meter.

14. Standardize the instrument according to the above procedure after every 50 samples. If the instrument has shown drift of 0.05 pH units or more, reread the last few samples to verify the accuracy of the recorded readings.

B. Daily Electrode Storage

1. Place the meter in the "Standby" mode.

2. Wash the electrode(s) with pure water.

3. Immerse the electrode(s) in pH 7.00 buffer solution.

C. Electrode Servicing

1. If the pH reading drifts, replace the glass electrode. Wait until the reading from the new electrode is stable. Usually, new electrode(s) should be kept in pH 7.00 buffer solution overnight before use.

2. After use, wash the electrode(s) with pure water.

3. Immerse the electrode(s) in pH 7.00 buffer solution.

VI. Electrical Conductivity Meter

Conductivity measurements must be made on solution samples only. The most common problem with conductivity meters concerns failure of the electrodes (mounted within the hollow plastic probe) to make proper contact with the solution. The probe must be kept clean by adequately flushing the interior of the probe with pure water. When analyzing a solution, insure that the solution covers the bottom 3 to 5 cm (1 to 1.5 inches) of the probe. Agitation of the probe in the unknown and standard solutions is required to obtain reproducible results. Agitation insures complete wetting of the internal electrodes by

removing any air bubbles using the solution of interest.

A. Calibration

1. Turn ON the "Supply" or "Power" switch.

2. Turn OFF the "Temperature Correction" switch (back panel).

3. Set the "Scale" wafer switch, if any, to read mmho/cm.

4. Place the conductivity probe into a standard solution of 0.005 M KCl. Agitate the probe using an up-and-down movement to create better solution to probe contact.

5. After agitation, the meter should read 0.72 ± 0.04 mmho/cm (0.72 ± 0.04 dS/m).

6. Agitate the probe again and reread the standard solution. Both the first and second readings should be the same value if the probe is in good contact with the solution.

7. Wash the probe with pure water on both inner (inject wash water through the hole at the top of the probe) and outer surfaces. Blot the probe dry. Do NOT rub the outer surface of the probe with the tissue paper.

8. Read the reference soil sample and verify that the current reading agrees with the known value for the reference soil (see Appendix for suggested acceptable variation).

9. Occasionally, "EEE" will appear on the instrument display indicating that the sample reading exceeds the current scale setting. Move the "Scale" wafer switch to the next highest position and reread the sample. This switch changes the reading by factors of 10. Note the correct decimal reading.

10. Record the entire meter reading including location of the decimal point.

11. Return the "Scale" wafer switch to the original position before reading the next sample.

ASSISTANCE FROM THE EXTENSION SOIL TESTING LABORATORY

The ESTL is available with the following forms of assistance:

1. A 4-hour In-Service training course is offered by the Director and Coordinator. This training course is designed as an on-site aid to all those county faculty, master gardeners, and other office personnel that handle or analyze soil and water samples. Operation of county equipment is checked using both electronic evaluation as well as comparison with ESTL equipment on the same samples.

2. Soil samples used for calibration of local lime recommendations can be analyzed for soil pH and Adams-Evans Buffer. This activity should be scheduled with the Director prior to sending samples.

3. Operation of county instrumentation can be checked at the ESTL. Instrument inspection by the Coordinator of the ESTL should be done by appointment.

4. Specific questions from county Extension faculty regarding pH and EC should be directed to the Director via IFAS VAX (user identification: HANLON) or telephone (904 392-1804).

LITERATURE

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APPENDIX

Soil pH Definition

The test for soil pH measures the acidity (pH less than 7.0) or alkalinity (pH greater than 7.0). If

the pH is equal to 7.0, then it is called neutral. The pH scale ranges from 1 to 14; however, most soils in Florida fall between 4 and 8.5. The following equation defines pH:

$$\text{Soil pH} = -\log(H^+).$$

In words, soil pH is equal to the negative logarithm of the hydrogen ion activity. Activity is related to concentration and activity is usually somewhat less than concentration in soil systems. From a horticultural or agronomic viewpoint, plant roots are "experiencing" the activity, not the concentration, effects of the hydrogen ion.

Reference Soil Sample

A reference soil sample is a sample which is analyzed each time pH and/or EC are analyzed. The source of the sample should be such that sufficient volumes can be taken for use by the county laboratory. A sample of 3 to 5 pounds of air dried soil can be used for several months by most county laboratories.

The sample should be completely air dried and then sieved to pass a 2-mm screen. The sample should be thoroughly mixed and stored in a dry location. A working subsample may be kept in the laboratory conveniently in a cylindrical cardboard container (e.g., used for ice cream). When the subsample has been used to the point where the remainder occupies less than about 1/3 of the container, it should be refilled from the main sample.

The subsample should be mixed before each use by inverting the container several times. Mixing prevents separation of the finer particles from the coarser particles.

The subsample results should be recorded at least once per use. The ESTL runs one reference soil sample for every 20 soil samples. If drift greater than $\pm$ 0.2 pH units or $\pm$ 0.05 dS/m is noted, then the instrument should be recalibrated and/or repairs made before continuing with unknown samples. If recalibration corrects the problem, several previously analyzed samples should be re-read to confirm the observed values. It is the intent of this procedure to provide high quality pH and EC readings by verifying that the instruments are reproducing the reference soil sample values correctly.

ACKNOWLEDGEMENTS