



## **SIW-1 SOIL AND IRRIGATION WATER MANUAL**

# TABLE OF CONTENTS

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	Page
<b>PREFACE</b>	
References . . . . .	iii
<b>SECTION 1 INTRODUCTION</b>	
Using This Manual . . . . .	1
Extracting Soil Samples . . . . .	1
Extraction Guide . . . . .	1
Using The Apparatus in the Kit . . . . .	2
Reading the Meniscus in Droppers and Cylinders . . . . .	2
Using The Color Comparator . . . . .	2
Using the Soil Scoops . . . . .	3
<b>SECTION 2 SAMPLE COLLECTION AND PREPARATION</b>	
Sampling, Drying, Grinding and Screening Soil Samples . . . . .	4
Filtering Soil Extracts . . . . .	5
Obtaining Water Samples . . . . .	5
<b>SECTION 3 SOIL EXTRACTION PROCEDURES</b>	
Aqueous Extraction (for salinity and pH) . . . . .	6
Calcium Sulfate Extraction (for nitrate-nitrogen) . . . . .	8
Mehlich 2 Extraction (for calcium + magnesium, phosphorus, potassium) . . . . .	10
Potassium Chloride Extraction (for total exchangeable acidity) . . . . .	12
Saturated Calcium Sulfate Extraction (for gypsum requirement and exchangeable sodium) . . . . .	14
SMP Buffer Extraction (for lime requirement) . . . . .	16
<b>SECTION 4 SOIL ANALYSIS PROCEDURES</b>	
Cation Exchange and Percent Base Saturation Calculation . . . . .	18
Gypsum Requirement—EDTA titration method . . . . .	19
Calcium + Magnesium—EDTA titration method . . . . .	21
Free Lime Estimation . . . . .	23
Lime Requirement—Electrode method . . . . .	25
Nitrate-Nitrogen—Cadmium Reduction method . . . . .	29
pH—Electrode method . . . . .	32
Phosphorus—Ascorbic Acid method . . . . .	34
Potassium, Exchangeable—Turbidimetric Tetraphenylborate method . . . . .	37
Salinity (Conductivity)—Electrode method . . . . .	39
Texture Estimation . . . . .	41
Total Exchangeable Acidity—NaOH titration . . . . .	43
<b>SECTION 5 IRRIGATION WATER ANALYSIS PROCEDURES</b>	
Conductivity—Electrode method . . . . .	45
Calcium + Magnesium—EDTA titration method . . . . .	47
Nitrate-Nitrogen—Cadmium Reduction method . . . . .	49
pH—Electrode method . . . . .	51
Phosphorus—Ascorbic Acid method . . . . .	53
Sodium Estimation and Sodium Adsorption Ratio Calculations . . . . .	55
<b>ORDERING AND TECHNICAL ASSISTANCE</b> . . . . .	56

# SIW-1 SOIL TEST KIT MANUAL

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## PREFACE

This test kit provides basic analyses for soil fertility assessment and irrigation water quality when routine laboratory analysis is not convenient or economical. This includes remote areas where facilities are not available or in a classroom where an instructor wants to present the basics of soil analysis without using expensive or sophisticated equipment. Prepackaged chemicals, simplified equipment and easy-to-follow procedures make Hach methods easy and quick to use.

The test kit was designed to meet the needs of professional scientists and non-scientists alike. Every possible effort was made to insure the results will be meaningful and applicable. The data obtained should lead the analyst to interpretations that correlate with interpretations from a competent full service soil laboratory. When possible, Hach Company used proven and accepted methodology in this kit. The procedures in this manual were modified from the following books and publications.

1. Handbook on Reference Methods For Soil Testing, Revised Edition—1980  
The Council On Soil Testing and Plant Analysis  
1111 Plant Science Building  
University of Georgia  
Athens, Georgia
2. Recommended Chemical Soil Test Procedures for the North Central Region  
Bulletin No. 499 (Revised)  
North Central Regional Publication No. 221 (Revised)  
North Dakota Agricultural Experiment Station  
North Dakota State University  
Fargo, North Dakota 58105
3. Diagnosis and Improvement of Saline and Alkali Soils  
Agricultural Handbook No. 60  
United States Department of Agriculture  
Issued February 1954 (Out of Print)  
Compiled by the United States Salinity Laboratory Staff
4. Methods of Soil Analysis, Part 2  
American Society of Agronomy  
Madison, Wisconsin  
1965
5. Soil Testing and Plant Analysis, Third Edition  
Soil Science Society of America, Inc.  
1991



# SECTION 1 INTRODUCTION

---

## SOIL AND IRRIGATION WATER MANUALS

The two manuals supplied with this kit acquaint users with Hach procedures and techniques necessary for soil and irrigation water characterization. *The Soil and Irrigation Water Manual—SIW-1* contains directions for performing the analyses. This manual has been printed on special waterproof, tear-resistant paper.

The *Hach Soil and Irrigation Water Interpretation Manual* helps interpret the results by providing basic information on soil fertility, soil characterization, plant nutrition, fertilizer recommendation, and irrigation water quality. This manual also contains a section on common conversion factors used in soil and water analysis, a glossary of terms, reorder information, and technical support information. The final pages of the manual contain data recording sheets to help the analyst record data and calculations from the analyses.

## USING THIS MANUAL

This manual is arranged in sequential sections. The first section acquaints the reader with some of the equipment and analytical techniques used with the apparatus. The second section covers sampling and sample preparation for analysis. Soil Extractions are covered in the next section (see information below) and Section 4 contains the soil analysis procedures in alphabetical order. The last section contains the water analysis procedures.

## EXTRACTING SOIL SAMPLES

To analyze for a specific substance(s) in a soil, you often need to extract that substance from the soil with a solvent (extractant). The analysis is then completed on the solution containing the substance.

**This manual contains six extraction procedures. The following Extraction Guide outlines which extractions are used when analyzing for the specific substances or parameters listed below each extraction. It is important to use the indicated extraction. More than one type of extraction may be necessary for a given sample.**

## EXTRACTION GUIDE

---

### Aqueous Extraction

↓  
pH  
Salinity

### Calcium Sulfate Extraction

↓  
Nitrate-Nitrogen

### Mehlich 2 Extraction

↓  
Phosphorus  
Potassium  
Calcium  
Magnesium

### Potassium Chloride Extraction

↓  
Total Exchangeable Acidity

### Saturated Calcium Sulfate Extraction

↓  
Gypsum Requirement  
Exchangeable Sodium

### SMP Buffer Extraction

↓  
Lime Requirement

---

The Mehlich 2 Soil Extract was chosen for several reasons:

1. Mehlich 2 is a viable choice for phosphorus extraction from most types of soils.
2. This reagent will extract as much or more phosphorus from most soils than other common extracts, resulting in more color development and therefore more accurate visual comparison of the color.
3. Other macronutrients (i.e., potassium, calcium, and magnesium) are extracted with Mehlich 2, allowing for their measurement and subsequent determination of cation exchange capacity and percent base saturation.

Two methods for determining lime requirement are included in this manual. The SMP buffer method is used for soils that have a lime requirement above 2 tons/acre. For soils that have a lime requirement below 2 tons/acre or in tropicals soils with high reserves of aluminum, the determination of total exchangeable acidity should be considered.

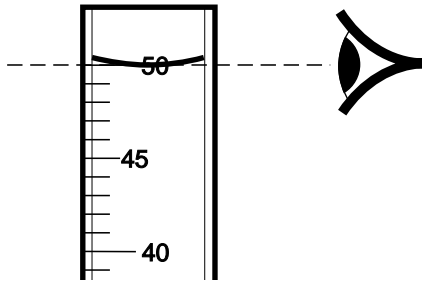
For convenience, soil salinity is determined with this kit using a 1:1 soil suspension instead of a saturated paste extract. However, where salinity management and leaching requirements are of prime importance, salinity should be determined using the traditional saturated paste method. Hach Company provides a Soil Saturation Extract Kit (Cat. No. 18700-00) to use with the Pocket Pal TDS Tester.

## USING THE APPARATUS IN THE KIT

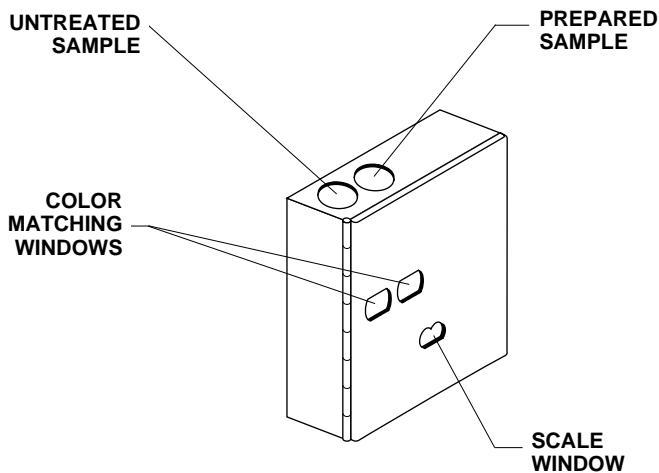
### Accurately Measuring Liquids Using Eye Droppers and Graduated Cylinders

When small sample quantities are used, the accuracy of measurements is important. Figure 1 below illustrates the proper technique for reading the sample level or the meniscus formed when the liquid wets the cylinder or wall of the dropper.

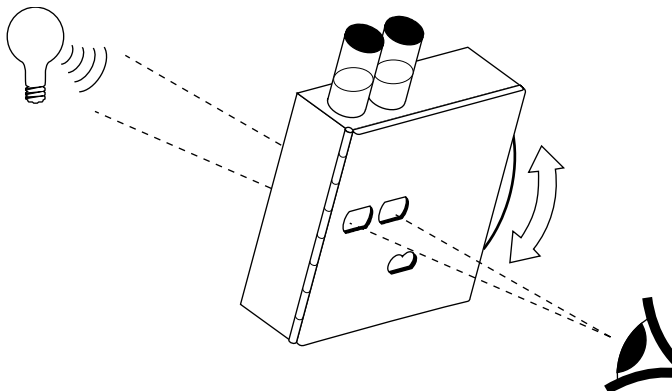
**FIGURE 1 READING THE MENISCUS**



**FIGURE 2 COLOR COMPARATOR**



**FIGURE 3**



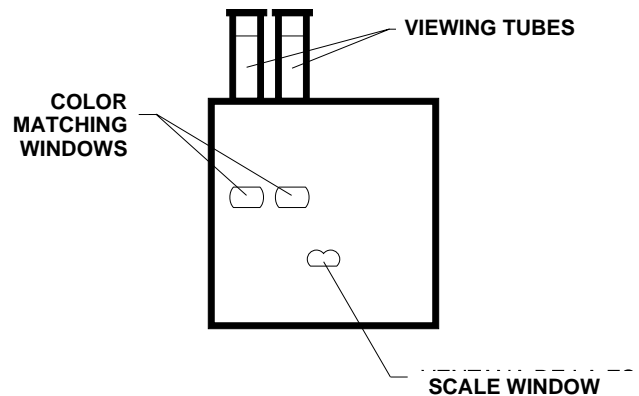
## USING THE COLOR COMPARATOR

The figures below illustrate how to use the Color Comparator to read the color viewing tubes. After color development:

1. Insert the blank (untreated sample) and sample (prepared sample) tubes in the correct openings (Figure 2).
2. Hold the Comparator so a light source is behind the Comparator as you look through the color matching windows (Figure 3).
3. Rotate the color disc until the color in the untreated sample window matches the color in the prepared sample window (Figure 4).
4. Read the concentration from the scale window.

*Note: The standards in the kit may be used to practice the technique for reading samples using the comparator.*

**FIGURE 4**



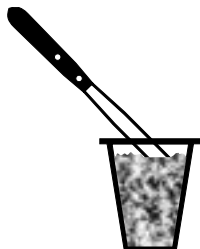
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## USING THE SOIL SCOOPS

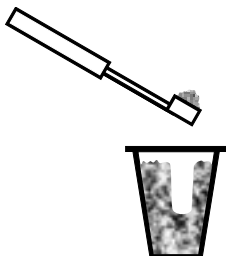
A set of soil scoops is included with the kit for sample measurement. The set consists of three different sized scoops: 0.85 cc (1 g), 1.70 cc (2 g), and 4.25 cc (5 g). In addition, a 0.1 g spoon is included for use in the procedures.

### Use the following procedure when using the scoops

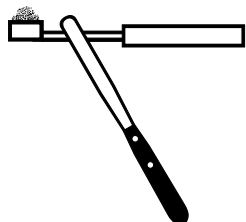
1. Use a spatula to stir the soil sample.



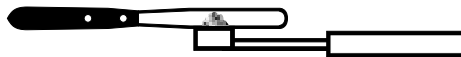
2. Dip the scoop into the center of the soil sample to obtain a heaping scoop full.



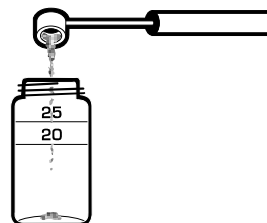
3. Hold the scoop firmly and tap the handle of the scoop sharply three times with a spatula to settle the soil.



4. Hold the blade of the spatula perpendicular to the top of the scoop and strike off the excess soil.



5. Empty the soil into the appropriate container for a given procedure.



# SECTION 2 SAMPLE COLLECTION AND PREPARATION

## SOIL PREPARATION

### SAMPLING, DRYING, GRINDING AND SCREENING

The following method is commonly used to prepare soil samples for subsequent testing. It applies to all classes of soils. The procedure is based on the *Recommended Chemical Soil Test Procedures for the North Central Region, Bulletin No. 499 (Revised)*, October, 1980 published by The North Dakota Agricultural Experiment Station, North Dakota State University.

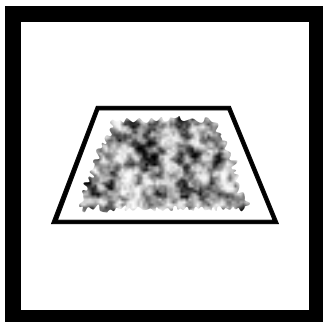
### SOIL SAMPLING

For meaningful results, it is of utmost importance that the soil sample be representative of the area being tested.

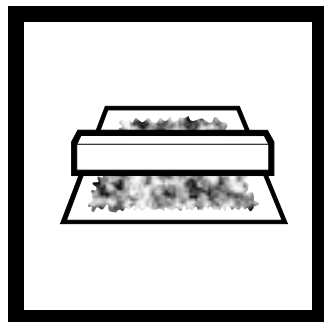
Depending on the size of the sampling area, take 15 to 20 subsamples from the area being sampled and mix them together in a clean container. Use a sample of this mixture during analysis to represent the area being tested. Subsamples (which should be approximately the same size) may be obtained with a coring tube, soil auger or shovel. Avoid sampling very unusual areas such as old manure piles, lime piles, fence lines, etc. **REMEMBER THE TEST RESULTS CAN NO BETTER REPRESENT THE TESTING AREA THAN DOES THE SOIL SAMPLE FROM THAT AREA.** The most valid information regarding sampling can be obtained from the local extension office.

Sample preparation consists of drying, crushing, mixing and sieving. These steps assure that a correct, representative sample is analyzed. Dry the sample as outlined below.

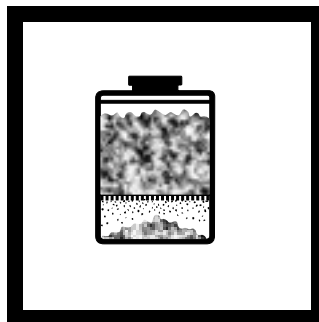
### DRYING PROCEDURE



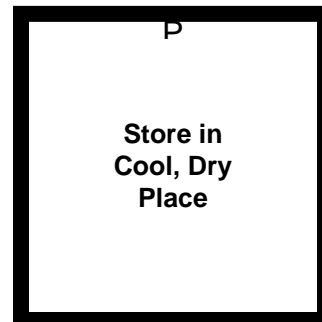
**1.** Break up the large chunks of soil and spread it out to air dry. Avoid contamination by fertilizer dusts or other such sources of contamination. If a forced-draft oven or similar drying device is used, set the heat no higher than 60 °C (140 °F).



**2.** Use a short 2x4 board or similar device to crush the air dried soil.



**3.** Pass the crushed soil through the 10-mesh (2 mm) soil sieve assembly included with the kit.



**4.** Store the soil in a cool, dry place until the analysis is complete.



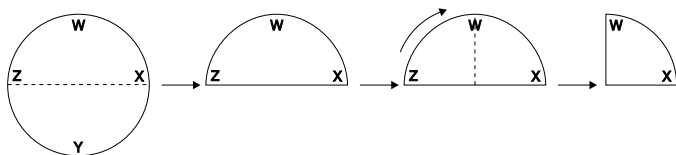
**5.** It is always wise to save samples being analyzed in case re-testing is necessary.



## FILTERING SOIL EXTRACTS

### Prepare a filter for filtration as follows:

1. Fold a piece of filter paper as illustrated in Figure 5.
2. Open the filter in a manner that forms an inverted cone. Check the filter paper for holes or tears—they can make the results inaccurate.
3. Rinse the funnel with deionized water. Shake the funnel to remove excess water.
4. Place the filter paper in the funnel.
5. Place the funnel into a round sample bottle or plastic cup to collect the extract.



**FIGURE 5 FOLDING THE FILTER PAPER**

*Fold a sheet of filter paper by creasing it in half and then in half again. Separate one edge from the other three to form a cone. Place the folded paper in the funnel.*

## OBTAINING WATER SAMPLES

The minimum volume of water recommended for analysis is approximately 1 liter. Take care to obtain a representative sample. Satisfactory samples of some waters can be obtained only by mixing several portions collected at different times. Collection and mixing technique depend on local conditions:

- Samples from wells should be collected after the pump has run for 10 minutes
- Samples from streams should be taken from running water

In general, the shorter the elapsed time between collection and analysis of a sample, the more reliable the analytical data will be. Changes resulting from chemical and biological activity may alter the composition of the sample.

### Use the following procedure to obtain a water sample:

1. Rinse the sample container 3 times with the water to be analyzed.
2. Fill the container completely full with the water to be analyzed and cap tightly.
3. Analyze the sample as soon as possible.

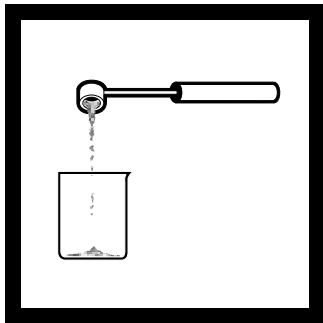
# SECTION 3 SOIL EXTRACTION PROCEDURES

## Aqueous Extraction Method for Soil Used for: Salinity and pH

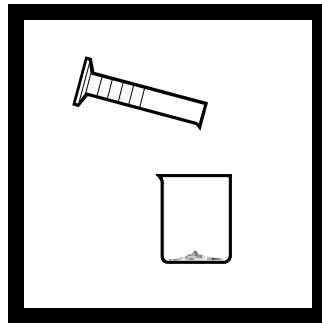
Use the Aqueous Extraction method to prepare the soil sample for salinity and pH measurements. The soil suspension does not need to be filtered to determine pH and salinity—measurements can be made directly in the suspension.

Before extraction, dry the soil sample, then screen it to a fineness of 0-2 mm using the Hach Soil Sieve in the kit. Careful preparation is important to assure volumetric measurement of the soil sample. Refer to the introductory sections for soil sampling and sample preparation.

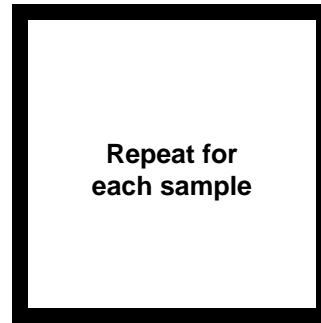
### AQUEOUS EXTRACTION PROCEDURE



**1.** Using a 5-gram scoop, measure 4 scoops of the prepared soil sample into a 50 mL plastic beaker.



**2.** Using a 25-mL graduated cylinder, accurately measure 20 mL of deionized water and transfer it to the 50-mL beaker.



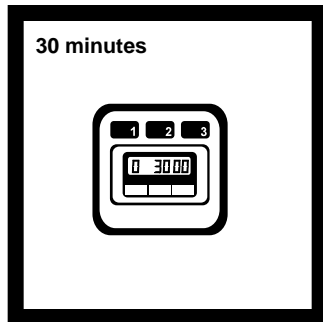
**3.** Repeat steps 1 - 2 for each soil sample undergoing extraction.

*Note: To prevent confusion when working with several samples, label each beaker with the sample or test name.*



**4.** Using the spatula, stir the contents of the beaker for 1 minute at 10-minute intervals over a 30 minute period.

*Note: Rinse the spatula with deionized water before stirring each sample.*



**5.** After 30 minutes, use the prepared sample for salinity and pH determination.

*Note: Because conductivity is affected by minute amounts of potassium chloride resulting from pH determination, measure the salinity of the sample before measuring pH.*

## AQUEOUS EXTRACTION, continued

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### APPARATUS

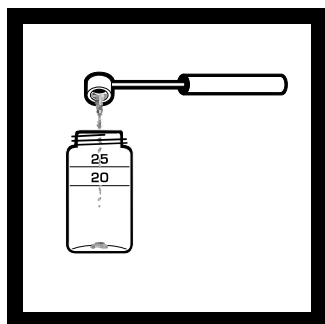
	<b>Cat. No.</b>
Beaker, Polypropylene, 50 ml . . . . .	1080-41
Cylinder, Graduated, Polymethylpentene, 25 ml . . . . .	2172-40
Soil Scoop, 5 g . . . . .	22628-05
Soil Sieve . . . . .	46159-00
Spatula, Stainless Steel . . . . .	561-62

## Calcium Sulfate Extraction For Soil Used for: Nitrate-Nitrogen

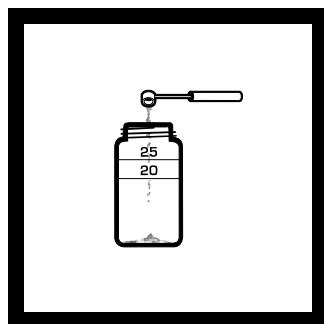
The Calcium Sulfate Extraction is used to extract nitrate-nitrogen from soils and can be used for all classes of soils.

Before extraction, dry the soil sample, then screen to a fineness of 0-2 mm using the Hach Soil Sieve in the kit. Careful preparation is important to assure volumetric measurement of the soil sample. Refer to the introductory sections for soil sampling and sample preparation.

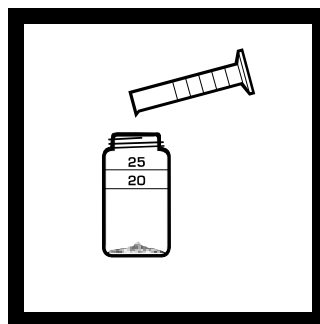
### CALCIUM SULFATE EXTRACTION PROCEDURE



**1.** Using a 5-gram soil scoop, measure 2 scoops of the prepared soil sample into a round sample bottle.



**2.** Using the 0.1-gram plastic spoon, add 1 level spoonful of Calcium Sulfate to the round sample bottle containing the sample.

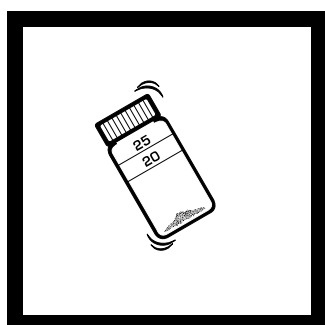


**3.** Using a 25-mL graduated cylinder, accurately measure 20 mL of deionized water into the cylinder and transfer it to the round mixing bottle.

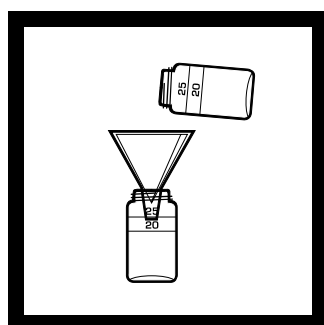


**4.** Repeat steps 1–3 for each soil sample undergoing extraction.

*Note: To prevent confusion when working with several samples, label each sample bottle with the sample or test name.*



**5.** Cap and shake each bottle vigorously for 1 minute.



**6.** Using a plastic funnel and filter paper, filter the contents of the bottle into another round sample bottle.



**7.** Analyze this extract for nitrate-nitrogen within 2 hours. If this is not possible, then the extract may be refrigerated for 24 hours before analysis.

*Note: The colorimetric test for nitrate-nitrogen is temperature sensitive. If the extract has been refrigerated, allow it to return to room temperature before analyzing.*

## CALCIUM SULFATE EXTRACTION, continued

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### REAGENTS

Description	Cat. No.
Calcium Sulfate Powder, 20 grams .....	12321-20

### APPARATUS

Bottle, Mixing, Round .....	18624-00
Cylinder, Graduated, Polymethylpentene, 25 ml .....	2172-40
Filter Paper, Circular, 15 cm .....	506-58
Funnel, Polyethylene, 82 mm .....	24155-82
Measuring Spoon, 0.1 g .....	511-00
Soil Scoop, 5.0 g .....	22628-05
Soil Sieve .....	46159-00

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## Mehlich 2 Extraction For Soil

### Used for: Calcium + Magnesium, Phosphorus, Potassium

The Mehlich 2 Soil Extractant is used for extracting calcium and magnesium, phosphorus, and potassium from soils. It is suitable for most classes of soils. With highly calcareous soils, calcium and magnesium results will be artificially high.

Before extraction, dry the soil sample, then screen it to a fineness of 0-2 mm using the Hach Soil Sieve in the kit. Careful preparation is important to assure volumetric measurement of the soil sample. Refer to the introductory sections for soil sampling and sample preparation.

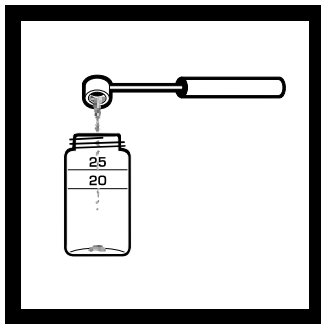
### PREPARING THE MEHLICH 2 EXTRACTANT

Prepare the Mehlich 2 Soil Extractant as follows:

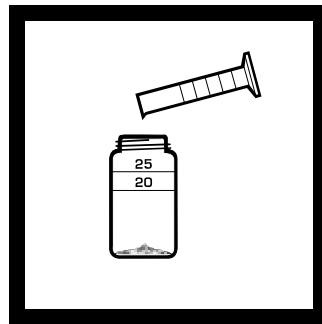
1. Measure 20 ml of the Mehlich 2 Soil Extractant Concentrate into a 25-ml graduated cylinder.
2. Transfer the extractant concentrate to one of the flip-top dispensing bottles provided.
3. Add deionized water to the dispensing bottle until the volume reaches the bottom of the neck. Invert several times to mix.
4. Using the laboratory pen, label the bottle with the extractant name to avoid confusion when working with other extractants. The Mehlich 2 Soil Extractant is now ready for use.

---

### MEHLICH 2 EXTRACTION PROCEDURE



1. Using a 2-gram scoop, measure 1 scoop of the prepared soil sample into a round sample bottle.



2. Using a 25-mL graduated cylinder, accurately measure 20 mL of the diluted Mehlich 2 Soil Extractant into the cylinder, then transfer it to the round sample bottle.



3. Repeat steps 1–2 for each soil sample undergoing extraction.

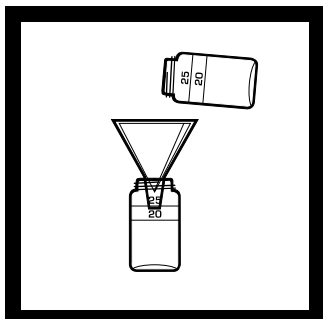
*Note: To prevent confusion when working with several samples, label each sample bottle with the sample or test name.*



4. Cap and shake each bottle for 5 minutes.

## MEHLICH 2 EXTRACTION, continued

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**Use for:**  
**Calcium**  
**Magnesium**  
**Phosphorus**  
**Potassium**

**5.** Using a plastic funnel and filter paper, filter the contents of the bottle into another round sample bottle.

**6.** Use this filtered extract for calcium + magnesium, phosphorus, and potassium, analysis.

*Note: The filtered Mehlich 2 Soil Extract is stable for approximately 24 hours. If stored longer, refrigerate to prevent microbial growth.*

*Note: The volume of extract obtained from the filtration should be adequate for the analysis of calcium + magnesium, phosphorus and potassium.*

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### REAGENTS

#### Description

#### Cat. No.

Soil Extractant Concentrate, Mehlich 2, 1 L . . . . . 22663-53

### APPARATUS

Bottle, Mixing, Round . . . . .	18624-00
Bottle, Polyethylene with Cap, 200 ml. . . . .	5909-00
Cylinder, Graduated, Polymethylpentene, 25 ml. . . . .	2172-40
Filter Paper, Circular. . . . .	506-58
Funnel, Polyethylene, 82 mm. . . . .	24155-82
Soil Scoop, 2 g . . . . .	22628-02
Soil Sieve . . . . .	46159-00
Sprinkler, with screen . . . . .	5912-00

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## Potassium Chloride Extraction For Soil Used For: Total Exchangeable Acidity

The Potassium Chloride Extraction is used to prepare the soil sample for total exchangeable acidity determination.

Before extraction, dry the soil sample, then screen to a fineness of 0-2 mm using the Hach Soil Sieve in the kit. Careful preparation is important to assure volumetric measurement of the soil sample. Refer to the introductory sections for soil sampling and sample preparation.

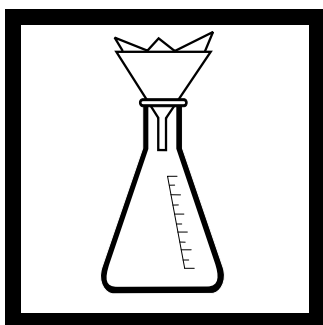
### PREPARING THE POTASSIUM CHLORIDE EXTRACTANT

To prepare an approximate 1.0 N KCl solution:

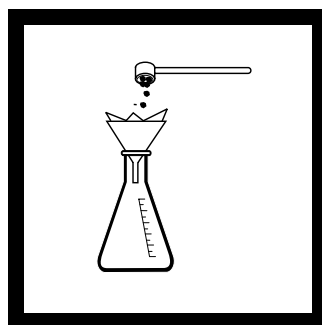
1. Add three 5-gram scoops of potassium chloride salt to one of the flip-top dispensing bottles.
2. Add deionized water to the dispensing bottle until the volume reaches the bottom of the neck.
3. Invert the bottle several times to mix.
4. Using the laboratory pen, label the bottle with the extractant name to avoid confusion when working with other extractants. This is enough KCl solution for 4 tests.

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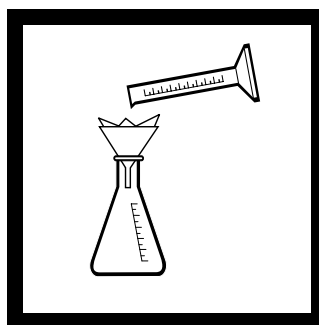
### POTASSIUM CHLORIDE EXTRACTION PROCEDURE



**1.** Place a filter into a funnel and moisten it with deionized water. Place a 125-mL erlenmeyer flask under the funnel to collect the filtrate.



**2.** Using a 5-gram scoop, measure 1 scoop of the prepared soil sample into the funnel containing the wetted filter paper.



**3.** Using the 50 ml graduated cylinder, slowly add 50 mL of 1.0 N KCl solution to the soil sample in 10-mL increments over a 2 hour period. After the addition is complete, rinse the soil sample twice with 10 mL of deionized water. Collect all of the filtrate from this step in the 125-mL erlenmeyer flask.



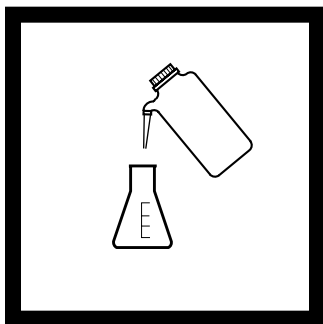
**4.** Repeat steps 1–3 for each soil sample undergoing extraction.

*Note: To prevent confusion when working with several samples, label each flask with the sample or test name.*



## POTASSIUM CHLORIDE EXTRACTION, continued

---



**5.** Add water to the 125 mL erlenmeyer flask to about the 75 mL mark. Use this filtrate for the determination of total exchangeable acidity.

---

### REAGENTS

#### Description

#### Cat. No.

Potassium Chloride, 454 g ..... 764-01

### APPARATUS

Bottle, Polyethylene with Cap, 200 ml. .... 5909-00  
Cylinder, Graduated, Polymethylpentene, 50 ml. .... 2172-41  
Filter Paper, Circular. .... 506-58  
Flask, Erlenmeyer, Polymethylpentene, 125 ml ..... 20898-43  
Funnel, Polyethylene, 82 mm. .... 24155-82  
Soil Scoop, 5 g ..... 22628-05  
Soil Sieve ..... 46159-00

---

## Saturated Calcium Sulfate Extraction For Soil Used For: Gypsum Requirement and Exchangeable Sodium

This procedure prepares the sample for determination of gypsum requirement. By calculation, the analyst can also estimate the meq/100 grams of exchangeable sodium in the soil. The procedure is based on the principle that the calcium ions in the saturated solution of  $\text{CaSO}_4$  will replace the exchangeable sodium in the extract. The number of milliequivalents of sodium displaced will equal the number of  $\text{Ca}^{2+}$  milliequivalents extracted from the saturated  $\text{CaSO}_4$  solution.

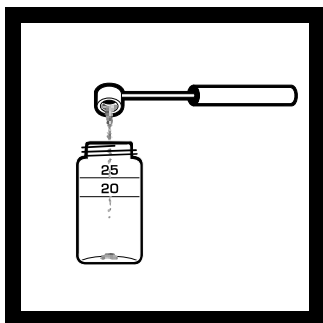
Before extraction, dry the soil sample, then screen to a fineness of 0-2 mm using the Hach Soil Sieve in the kit. Careful preparation is important to assure volumetric measurement of the soil sample. Refer to the introductory sections for soil sampling and sample preparation.

### PREPARING THE SATURATED CALCIUM SULFATE EXTRACTANT

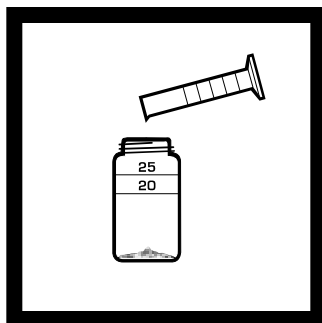
1. Using the 1-gram soil level scoop, add one level scoop of calcium sulfate to a flip-top dispensing bottle.
2. Add deionized water to the dispensing bottle until the volume reaches the bottom of the neck.
3. Shake the solution vigorously several times over a 30 minute period to dissolve the calcium sulfate. A small amount of the calcium sulfate may not dissolve.
4. Using the laboratory pen, label the bottle with the extractant name to avoid confusion when working with other extractants.

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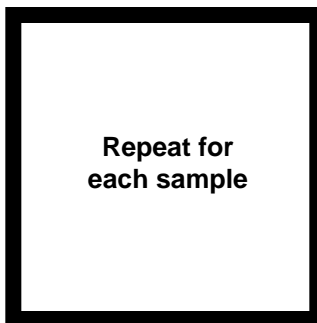
### CALCIUM SULFATE EXTRACTION PROCEDURE



1. Using the 1-gram soil scoop, measure 1 scoop of the prepared soil sample into a round sample bottle.

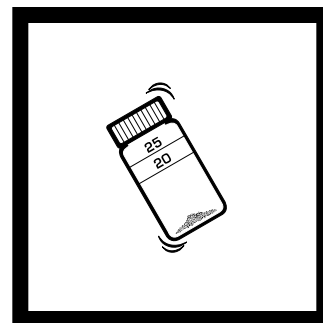


2. Using a 25-ml graduated cylinder, accurately measure 20 mL of the saturated calcium sulfate solution, and transfer it to the round sample bottle containing the soil sample.



3. Repeat steps 1-2 for each soil sample undergoing extraction.

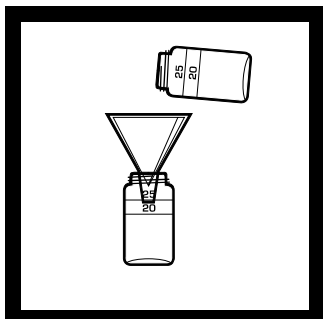
*Note: To prevent confusion when working with several samples, label each sample bottle with the sample or test name.*



4. Cap and shake each bottle for 1 minute at 10 minute intervals over a 30 minute period.

## SATURATED CALCIUM SULFATE EXTRACTION, continued

---



**Use for:**  
**gypsum requirement**  
**exchangeable sodium**

**5.** Using a plastic funnel and filter paper, filter the contents of the bottle into another round sample bottle.

**6.** Use this filtered extract for the determination of gypsum requirement and exchangeable sodium.

---

### REAGENTS

#### Description

Description	Cat. No.
Calcium Sulfate, 20 grams .....	12321-20

### APPARATUS

Bottle, Mixing, Round .....	18624-00
Bottle, Polyethylene with Cap, 200 ml. ....	5909-00
Cylinder, Graduated, polymethylpentene, 25 ml. ....	2172-40
Filter Paper, Circular. ....	506-58
Funnel, Polyethylene, 82 mm. ....	24155-82
Soil Scoop, 1 g .....	22628-01
Soil Sieve .....	46159-00

---

## SMP Buffer Extraction For Soil Used For: Lime Requirement

The SMP Buffer Extraction is designed for soils with large lime requirements and large reserves of exchangeable aluminum (Al). **The procedure may be inappropriate for:**

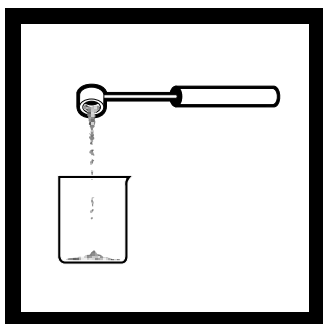
- low lime requirement soils (< 2 tons/ acre or 2,240 kg/Ha)
- soils containing organic matter greater than 10%
- sandy soils
- soils with high levels of kaolinite and hydroxy oxides of aluminum and iron in their clay fractions.

The analysis of total exchangeable acidity may be more effective for determining the lime requirement in soils not suitable for the SMP Buffer method.

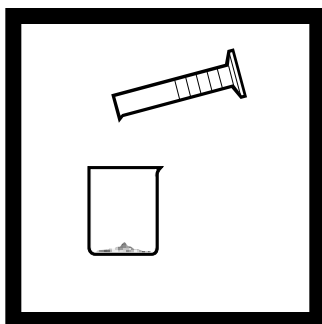
Before extraction, dry the soil sample, then screen to a fineness of 0-2 mm using the Hach Soil Sieve in the kit. Careful preparation is important to assure volumetric measurement of the soil sample. Refer to the introductory sections for soil sampling and sample preparation.

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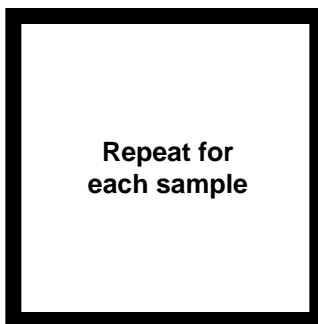
### SMP BUFFER EXTRACTION PROCEDURE



**1.** Using a 2-gram soil scoop, measure 4 scoops of the prepared soil sample into a 50-mL beaker.

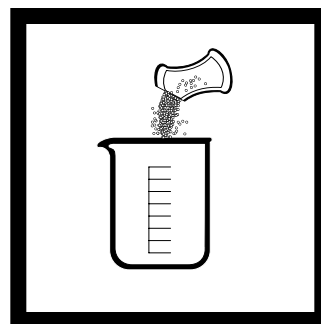


**2.** Using the 25-mL graduated cylinder, accurately measure 21 mL of deionized water and transfer it to the 50-mL beaker.



**3.** Repeat steps 1–2 for each soil sample undergoing extraction.

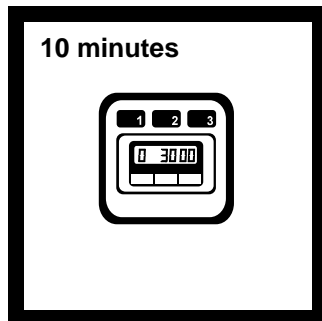
*Note: To prevent confusion when working with several samples, label each beaker with the sample or test name.*



**4.** Add the contents of one Lime Requirement Buffer Pillow to each 50-mL beaker.

## SMP BUFFER EXTRACTION, continued

---



**5.** Using the spatula, stir the contents of the beaker for 1 minute and allow it to stand for 10 minutes.

*Note:* Rinse spatula with deionized water before stirring each sample.

**6.** After 10 minutes, use the prepared sample for lime requirement determination.

---

### REAGENTS

#### Description

Cat. No.

Lime Requirement Buffer Powder Pillows, 25/pkg. . . . . 14345-98

### APPARATUS

Beaker, Polypropylene, 50 ml . . . . . 1080-41  
Cylinder, Graduated, Polymethylpentene, 25 ml. . . . . 2172-40  
Soil Scoop, 2 g . . . . . 22628-02  
Soil Sieve . . . . . 46159-00  
Spatula, Stainless Steel . . . . . 561-62

## SECTION 4 SOIL ANALYSIS PROCEDURES

---

### Calculation Of Cation Exchange Capacity and Percent Base Saturation in Soil

The calculation of cation exchange capacity and percent base saturation requires previous determination of potassium, calcium + magnesium, sodium, and lime requirement.

Determining the cation exchange capacity (CEC) of soils is important for assessing supplemental potassium needs and the appropriate quantity of herbicides to apply to soils. Precise determination of CEC is time consuming. Soil testing labs in regions with acidic to neutral (pH 7) soils have determined that estimating the CEC by summing the exchangeable K, Ca, Mg, and neutralizable acidity (lime requirement) is acceptable (see equation below). Measurement of CEC for calcareous soils (pH >7) may be inflated by the CaCO<sub>3</sub> in the Mehlich 2 extract.

$$\text{CEC meq/100 grams} = \text{K} + \text{Ca} + \text{Mg} + \text{Na} + (\text{SMP Lime Requirement} \times 2)$$

The values for K, Ca, Mg, and Na are in meq/100 g, not in ppm. Refer to the *individual procedures* to insure the proper units. See the Gypsum Requirement procedure for calculating the Na value.

Rarely would summation include a numeric value for both Na and exchangeable acidity. Acidic soils have a lime requirement and are typically low enough in sodium that its value is insignificant in the CEC calculation. Soils that are alkaline have no lime requirement value and therefore the value should not be included in the calculation.

$$\% \text{ Base Saturation} = \frac{[\text{K} + \text{Ca} + \text{Mg} + \text{Na}] \times 100}{\text{CEC}}$$

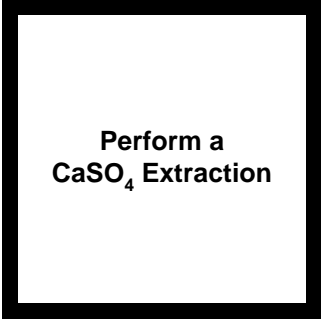
*Note: Cation values, K, Ca + Mg, Na must be as meq/100 g*

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## Gypsum Requirement For Soil EDTA Titration Method

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### PROCEDURE

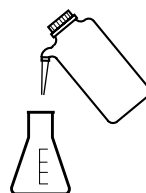


Perform a  
 $\text{CaSO}_4$  Extraction

**1.** Obtain a calcium sulfate extract for the soil sample by performing the Saturated Calcium Sulfate Extraction procedure in Section 3.



**2.** Using a 1.0-mL dropper, accurately transfer 1.0 mL of the sample extract prepared in Step 1 to a 50-mL erlenmeyer flask.



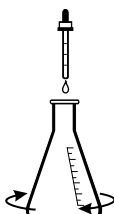
**3.** Add deionized water to about the 25-mL mark.



**4.** Add 1.0 mL of Buffer Hardness 1 solution to the flask and swirl to mix.

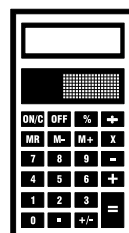


**5.** Add 3 to 4 drops of ManVer Hardness Indicator Solution to the flask and swirl to mix.



**6.** Titrate the sample by adding 0.0075 N EDTA Standard Solution dropwise to the flask while swirling. Keep an accurate count of the number of drops being added to the solution. Continue titrating until the color begins to change from wine red to pure blue.

*Note: If the sample contains high amounts of copper, the solution will reach endpoint without turning pure blue. If this happens, add titrant dropwise until no color change is visible.*



**7.** Calculate the gypsum requirement using the calculations following these steps.

*Note: If the number of drops of titrant are equal to or greater than 56, then no gypsum requirement exists.*



**8.** When analysis is complete, rinse the labware with deionized water.

## GYPSUM REQUIREMENT, continued

---

### CALCULATIONS

Gypsum Requirement (GR), (meq/100 gms) =

$$\left[ 28 - \left( \frac{\text{No. of Drops}}{2} \right) \right] \times 2$$

Gypsum Requirement (Tons/Acre) =

$$\text{GR meq per 100 grams} \times 1.7$$

Gypsum Requirement (Metric Tons/Ha) =

$$\text{GR meq per 100 grams} \times 3.81$$

Estimated Exchangeable Sodium (meq/100 grams) =

$$[ 0.96 + (0.99 \times \text{GR meq per 100 grams}) ]$$

Example

The analyst titrates 1.0 mL of saturated solution and it requires 50 drops of EDTA to obtain the endpoint.

$$\text{GR, meq/100 gms} = \left[ 28 - \left( \frac{50}{2} \right) \right] \times 2 = \mathbf{6 \text{ meq/100 grams}}$$

$$\text{GR, Tons/Acre} = 6 \times 1.7 = \mathbf{10.2 \text{ tons/acre}}$$

$$\text{GR, Kg/Ha} = 6 \times 3.81 = \mathbf{22.86 \text{ metric tons/hectare}}$$

$$\text{Est. Na meq/100 gms} = [0.96 + (0.99 \times 6)] =$$

$$\mathbf{6.9 \text{ meq/100 gms}}$$

---

### REAGENTS

#### Description

	Cat. No.
EDTA Standard Solution, 0.0075 N. . . . .	24981-32
Hardness 1 Buffer, 100 mL . . . . .	424-32
ManVer Hardness Indicator Solution, 100 mL . . . . .	425-32

### APPARATUS

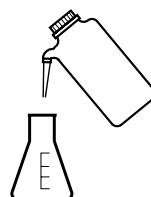
Dropper, Glass, 5/pkg . . . . .	14197-05
Flask, Erlenmeyer, Polymethylpentene, 50 ml . . . . .	20898-41



## Calcium + Magnesium in Soil EDTA Titration Method

### PROCEDURE

**Perform a  
Mehlich 2  
Extraction**

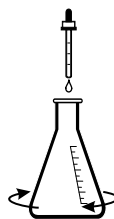
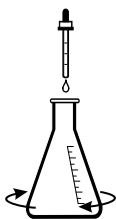


**1.** Obtain a Mehlich 2 extract for the soil sample by performing the Mehlich 2 Extraction procedure in Section 3.

**2.** Using a 1.0-mL dropper, accurately transfer 1.0 mL of the sample extract from Step 1 into a 50-mL erlenmeyer flask.

**3.** Add deionized water to about the 25-mL mark.

**4.** Add 1.0 mL of Buffer Hardness 1 Solution to the flask and swirl to mix.



**Calcium + Magnesium  
meq/100 grams =**  
$$\frac{\text{No. of Drops}}{2}$$

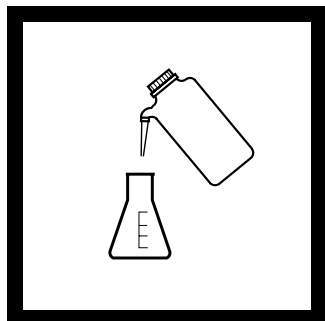
**5.** Add 3–4 drops of ManVer Hardness Indicator Solution to the flask and swirl to mix. If calcium and/or magnesium is present, the solution will turn wine red.

**6.** Titrate the sample by adding 0.0075 N EDTA Standard Solution dropwise to the flask while swirling. Keep an accurate count of the number of drops added to the solution. Continue titrating until the color begins to change from wine red to violet.

**7.** As the endpoint is approached, add titrant one drop at a time; swirl after each drop. Continue this until a drop of titrant no longer results in a visible color change. This is the endpoint of the titration. Record the total number of drops required to reach the endpoint. The solution will be blue or slightly violet.

**8.** Divide the number of drops of titrant by 2 to determine the meq/100 grams of calcium + magnesium.

*Note: If the sample contains significant amounts of copper the solution will reach endpoint without turning pure blue. If this occurs, add titrant dropwise until no color change is visible.*



**9.** When analysis is complete, rinse the labware with deionized water.

---

**REAGENTS**

<b>Description</b>	<b>Cat. No</b>
Buffer Solution, Hardness 1, 100 mL.....	424-32
EDTA Standard Solution, 0.0075 N.....	24981-32
ManVer Hardness Indicator Solution, 100 mL.....	425-32

**APPARATUS**

Dropper, Glass, 5/pkg. ....	14197-05
Flask, Erlenmeyer, Polymethylpentene, 50 ml.....	20898-41

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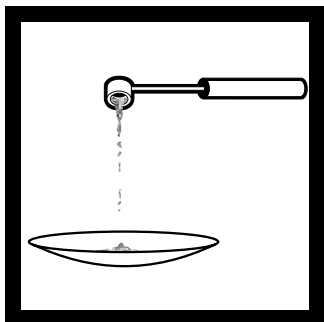
## Lime Estimation, Free (Excess) in Soil

A calcareous soil is alkaline in pH because it contains calcium carbonate particles. Calcareous soils effervesce (fizz) when treated with 2.5 N hydrochloric acid (HCl). The degree of effervescence determines whether the soil is non-calcareous, slightly, moderately, or highly calcareous.

Calcareous soils present several problems to crop management. While the soils are highly buffered against acidity (high % base saturation), the alkaline pH reduces the availability of phosphorus, iron, zinc, manganese, copper and boron.

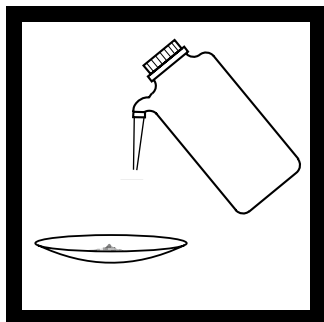
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### PROCEDURE

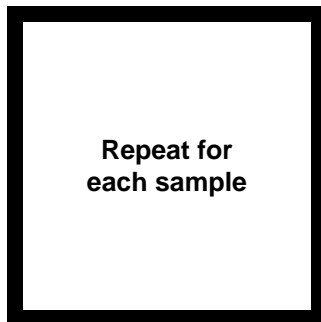


**1.** Using a 1-g scoop, measure 1 scoop of the prepared soil sample onto the watch glass provided.

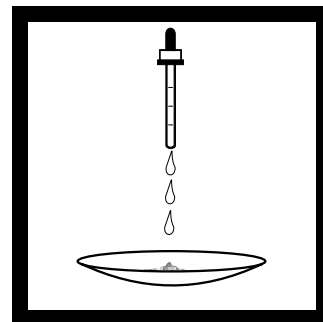
*Note: Several samples may be analyzed on the watch glass. Use the laboratory pen to divide the watch glass into sections and carefully label each section. Use one section per sample. Use care to prevent cross contamination between samples.*



**2.** Add deionized water dropwise to the soil until it is minimally saturated. This expels air from the sample, preventing erroneous results.

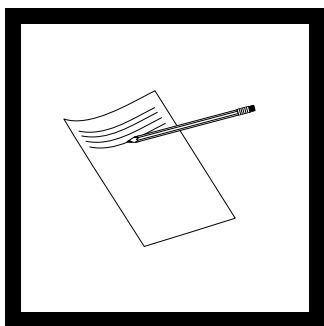


**3.** Repeat steps 1–2 for each soil sample undergoing analysis.



**4.** Add 3 drops of 2.5 N HCl to each soil sample and note the degree of effervescence.

*Note: It is helpful when first learning this procedure to test several soils of known pH and/or lime content to use as references.*



**5.** Record whether the soil is non-calcareous, slightly, moderately, or highly calcareous.

## LIME ESTIMATION, continued

---

### REAGENTS

Description	Cat. No.
Hydrochloric Acid Standard Solution, 2.5 N, 100 mL .....	1418-32

### APPARATUS

Pen, Laboratory .....	20920-00
Soil Scoop, 1 g .....	22628-01
Watch Glass, Pyrex .....	578-67

---

## Lime Requirement for Soil Electrode Method

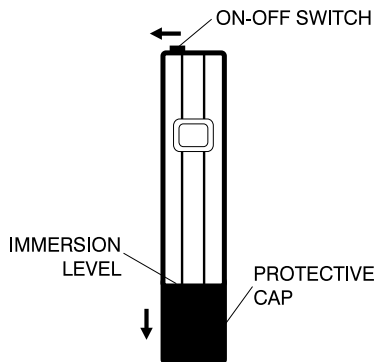
### PREPARATION

Calibrate the Pocket Pal pH Tester according to the directions below.

**A.** Prepare a pH 7.00 buffer solution by adding the contents of one pH 7.00 Buffer Powder Pillow to a 50-ml beaker containing 50 mL of water. Swirl the beaker until the contents are dissolved.

**B.** Slide the on/off switch located on the top of the Pocket Pal pH Tester to on.

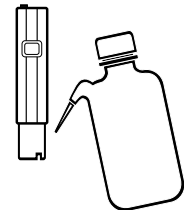
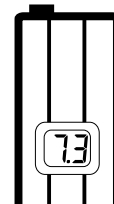
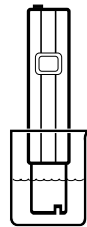
**C.** Remove the protective cap from the bottom of the instrument and immerse the pH electrode tip one inch below the surface of the buffer solution. If necessary, calibrate the instrument by adjusting the calibration screw near the pocket clip with the trim tool (screwdriver) provided to obtain a reading of 7.0.



---

### PROCEDURE

#### Perform a SMP Buffer Extraction



**1.** Obtain a SMP buffer extract for the soil sample by performing the SMP Buffer Extraction procedure in Section 3.

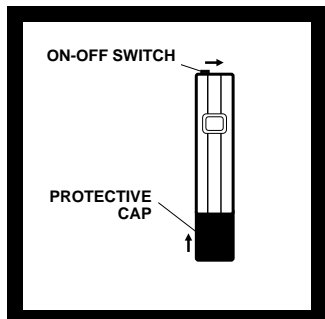
**2.** Immerse the tip of the calibrated Pocket Pal pH Tester one inch below the surface of the sample extract from Step 1 and stir gently until the soil is completely suspended and the pH reading is stable.

**3.** Record the pH reading to the nearest 0.1 pH unit. This is the buffer pH.

**4.** Rinse the pH electrode with deionized water. Remove the excess by wiping the tip with a tissue before continuing to the next sample.

## LIME REQUIREMENT, continued

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**See Lime  
Requirement Table**

**5.** Once the pH of each sample has been determined, rinse the electrode with deionized water. Slide the on/off switch of the Pocket Pal pH Tester to off and cover the electrode with the protective cap before storing.

**6.** Refer to the Lime Requirement Table following these steps to determine the actual Lime Requirement of the sample by using the experimentally obtained buffer pH value.

---

The most common acceptable method of determining lime requirement is to measure pH on an SMP extraction of the soil. In this method, a buffer is added to an acidic soil. The response of the soil, measured as an increase in pH, is related to the tons of lime (as  $\text{CaCO}_3$ ) needed per acre to raise the soil pH to either 6.5 or 7.0.

---

### REAGENTS

#### Description

	Cat. No.
Buffer Powder Pillows, pH 7, 50/pkg .....	22270-66

### APPARATUS

Beaker, Polypropylene, 50 ml .....	1080-41
pH Pocket Pal Tester .....	44350-00

**LIME REQUIREMENT TABLE**  
**Tons/Acre of Pure Limestone\* (as CaCO<sub>3</sub>) Required to Raise Buffer pH**

Buffer pH	To pH 7.0	To pH 6.5
6.8	0.1	0.1
6.7	0.7	0.6
6.6	1.2	1.0
6.5	1.9	1.6
6.4	2.7	2.3
6.3	3.4	2.9
6.2	4.2	3.6
6.1	5.1	4.3
6.0	5.7	4.8
5.9	6.7	5.7
5.8	7.5	6.4
5.7	8.4	7.1
5.6	9.1	7.7
5.5	9.8	8.3
5.4	10.7	9.1
5.3	11.5	9.8
5.2	12.4	10.5
5.1	13.1	11.1

The values in this table are based on tons of pure, fine CaCO<sub>3</sub> with a calcium carbonate equivalent (CCE) of 100.

If you wish to use limestone other than 100 CCE, then calculate the required tons as follows:

To determine the requirement of agricultural limestone or other lime materials, divide the number obtained from the table by the assayed CCE, expressed as a decimal percentage.

For example: If your buffer pH is 6.6, and you wish to raise the soil pH to 7.0, then 1.2 tons/acre of 100 CCE limestone should be incorporated into the top 8 inches of your soil. If the CCE of the limestone you wished to apply is assayed at 87, then you would need to apply 1.2/0.87, or 1.37 tons of that limestone to bring your soil to the desired pH.





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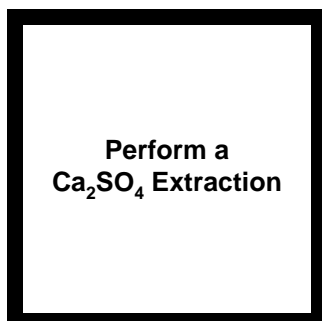
## Nitrate-Nitrogen in Soil (0-60 ppm) Cadmium Reduction Method

### PREPARATION

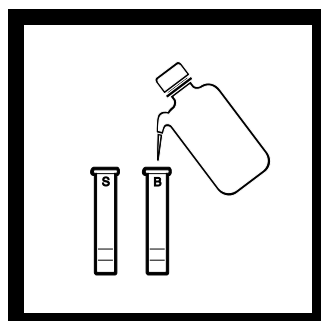
Place the High Range Nitrate Color Disc into the Color Comparator. Make sure it is inserted so the mg/L values are visible through the window of the Color Comparator.

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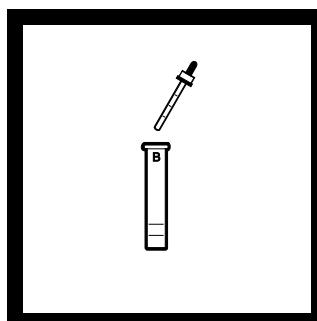
### PROCEDURE



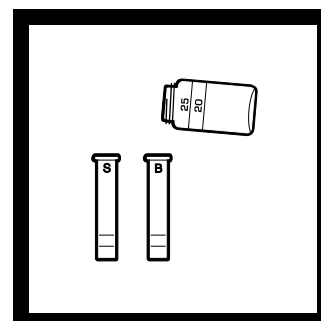
**1.** Obtain a calcium sulfate extract for the soil sample by performing the Calcium Sulfate Extraction procedure in Section 3.



**2.** Label 1 Color Viewing Tube "S" for sample and another Color Viewing Tube "B" for blank. Thoroughly rinse both Color Viewing Tubes with deionized water. Shake the tubes to remove the remaining rinse water.

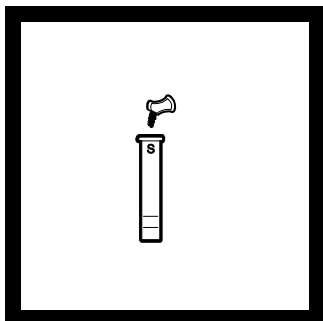


**3.** Add a small amount of the sample extract (about 1/4" deep) to the Color Viewing Tube marked "S". Cap the tube with a rubber stopper and shake it for a few seconds. Discard this solution.



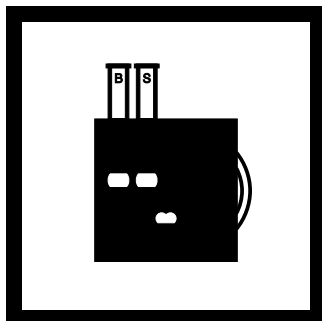
**4.** Add the extract to both tubes until the meniscus is even with the 5-mL mark (bottom of frosted area).

## NITRATE-NITROGEN IN SOIL, continued

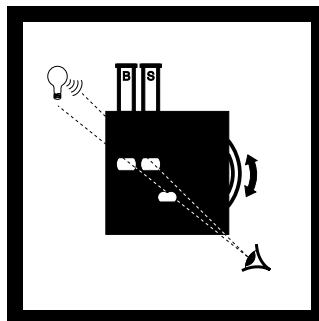


**5.** Add the contents of one NitraVer 5 Powder Pillow to the tube marked “S”. Cap and shake the tube vigorously for exactly one minute.

*Note: This kit contains a 15 mg/L nitrate-nitrogen standard so the analyst can learn proper shaking technique and use of the color wheel. It is suggested that the analyst practice with the standard until repeated results are within 1 mg/L of each other. The standard should read near 15 mg/L. If the experimental concentration is less than 14 mg/L or greater than 17 mg/L, repeat the procedure until satisfactory results are obtained.*



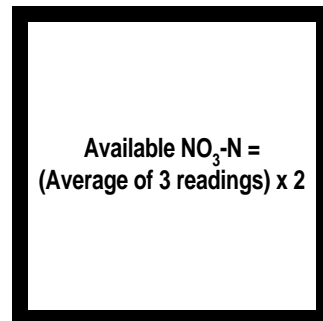
**6.** Immediately place tubes “S” and “B” into the comparator with tube “B” in the outside hole and tube “S” in the inside hole.



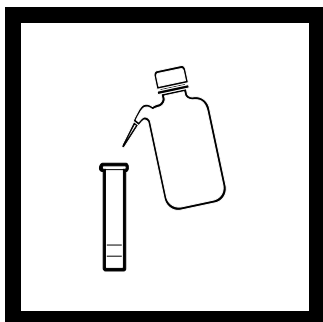
**7.** Five minutes after completing Step 6, hold the Color Comparator up to a light source. Rotate the disc until the color in the window for tube “B” matches the color in the window for tube “S”. Record the value in the scale window. Take two more readings of the sample, rotating the color disc between each reading. Complete all three readings within 10 minutes of completing Step 6.

*Note: Readings before 5 minutes or after 10 minutes will result in an inaccurate value.*

*Note: It is very important that the standard and the sample are viewed under the same lighting conditions.*



**8.** Take the average of the three readings and multiply it by 2 for the available nitrate-nitrogen value in the soil.



**9.** When analysis is complete, rinse the labware with deionized water. Shake dry. Store the color disc in the plastic bag provided.

## NITRATE-NITROGEN IN SOIL, continued

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### REAGENTS

Description	Cat. No.
NitraVer 5 Nitrate Reagent Powder Pillows, 100/pkg .....	14035-99

### APPARATUS

Color Comparator Box .....	1732-00
Color Viewing Tube with Caps, Plastic, pk/4 .....	46600-04
Nitrate Nitrogen, High Range, Color Disc .....	14038-00

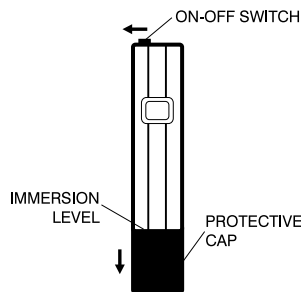
---

## pH in Soil Electrode Method

### PREPARATION

Calibrate the Pocket Pal pH Tester according to the directions below.

**A.** Prepare a pH 7.00 buffer solution by adding the contents of one pH 7.00 Buffer Powder Pillow to a 50-ml beaker containing 50 mL of water. Swirl the beaker until the contents are dissolved.



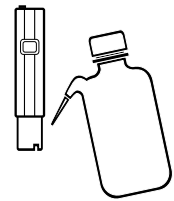
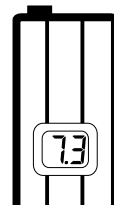
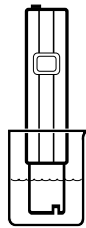
**B.** Slide the on/off switch located on the top of the Pocket Pal pH Tester to on.

**C.** Remove the protective cap from the bottom of the instrument and immerse the pH electrode tip one inch below the surface of the buffer solution. If necessary, calibrate the instrument by adjusting the calibration screw near the pocket clip with the trim tool (screwdriver) provided to obtain a reading of 7.

---

### PROCEDURE

#### Perform Aqueous Extraction

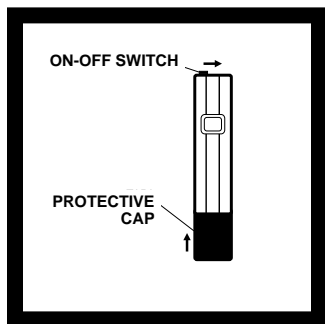


**1.** Obtain an aqueous extract for the soil sample by performing the Aqueous Extraction procedure in Section 3.

**2.** Immerse the tip of the calibrated Pocket Pal pH Tester one inch below the surface of the aqueous sample extract and stir gently until the soil is completely suspended.

**3.** Record the stabilized pH reading to the nearest 0.1 pH unit.

**4.** Rinse the pH electrode with deionized water. Remove the excess by wiping the tip with a tissue before continuing to the next sample.



**5.** Once the pH of each sample has been determined, rinse the electrode with deionized water. Slide the on/off switch of the Pocket Pal pH Tester to off and cover the electrode with the protective cap before storing.

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**REAGENTS**

**Description**

**Cat. No.**

Buffer Powder Pillows, pH 7, 50/pkg ..... 22270-66

**APPARATUS**

Beaker, Polypropylene, 50 ml ..... 1080-41  
Pocket Pal pH Tester ..... 44350-00  
Trim Tool (Screwdriver) ..... 18933-00

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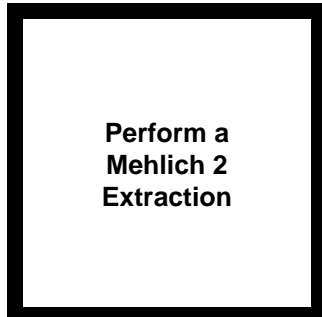
## Phosphorus in Soil (0-130 mg/L or 0-130 ppm) PhosVer 3 (Ascorbic Acid) Method

### PREPARATION

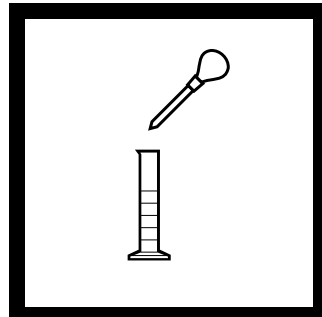
Place the Phosphate Color Disc into the Color Comparator.  
Make sure it is inserted so the mg/L values are visible through  
the window of the Color Comparator.

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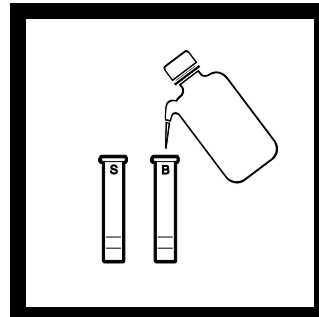
### PROCEDURE



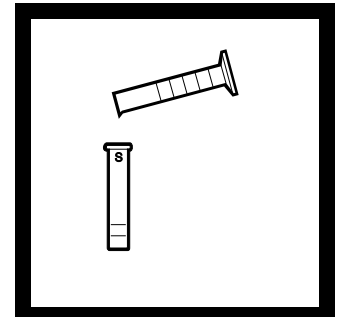
**1.** Obtain a Mehlich 2 extract for the soil sample by performing the Mehlich 2 Extraction in Section 3.



**2.** Using the 2.5-mL dropper, add 2.5 mL of the filtered sample extract prepared in Step 1 to a 25-mL graduated cylinder. Dilute to the 25 mL mark with deionized water, stopper, and invert to mix.

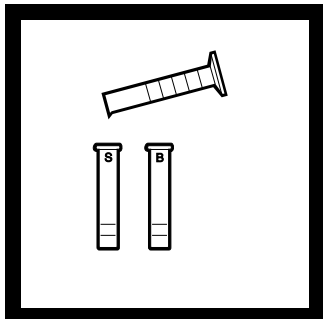


**3.** Label 1 Color Viewing Tube “S” for sample and another Color Viewing Tube “B” for blank. Thoroughly rinse both Color Viewing Tubes with deionized water. Shake the tubes to remove the remaining rinse water.

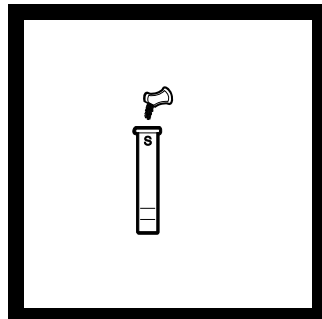


**4.** Add a small amount of the diluted extract (about 1/4" deep) to the Color Viewing Tube marked “S”. Cap the tube with a rubber stopper and shake it for a few seconds. Discard this solution.

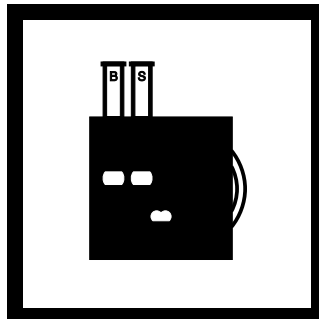
## PHOSPHORUS IN SOIL, continued



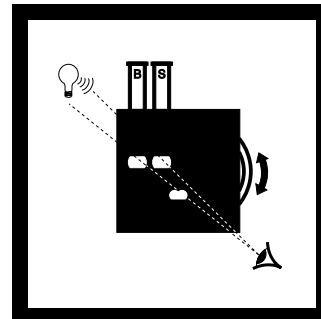
**5.** Add the diluted Mehlich 2 Extract to both tubes until the meniscus is even with the 5-mL mark on the tubes (bottom of frosted area).



**6.** Add the contents of one PhosVer 3 Powder Pillow to the "S" tube. Cap and shake the tube vigorously for one minute.



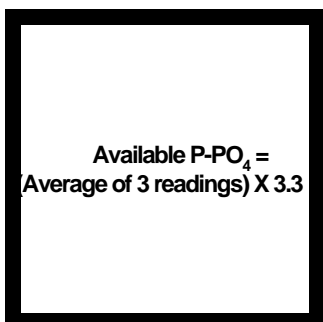
**7.** Immediately place tubes "S" and "B" into the comparator with tube "B" in the outside hole and tube "S" in the inside hole.



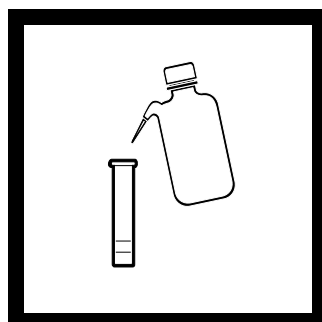
**8.** Three minutes after completing Step 6, hold the Color Comparator up to a light source. Rotate the disc until the color in the window for tube "B" matches the color in the window for tube "S". Record this value in the window. Take two more readings for the sample, rotating the color disc between each reading. Complete all three readings within 10 minutes of completing Step 7.

*Note: Readings before 3 minutes or after 10 minutes will result in an inaccurate value.*

*Note: It is very important that the sample is viewed under the same lighting conditions for all readings.*



**9.** Take the average of the three readings and multiply this average by 3.3 for the available phosphate-phosphorus value in the soil.



**10.** When analysis is complete, rinse the color viewing tubes with deionized water and store the color disc in the plastic bag provided.

## PHOSPHORUS IN SOIL, continued

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### REAGENTS

Description	Cat. No.
PhosVer 3 Phosphate Reagent Powder Pillows, 100/pkg . . . . .	2209-99

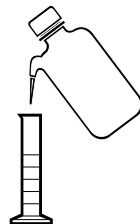
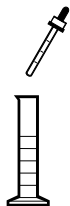
### APPARATUS

Color Comparator Box . . . . .	1732-00
Color Viewing Tube with Caps, Plastic, pk/4 . . . . .	46600-04
Dropper, Polyethylene, 2.5 ml . . . . .	17045-00
Phosphate, High Range, Color Disc . . . . .	24898-00



## Potassium (Exchangeable) in Soil (0-250 mg/L or 0-250 ppm) Turbidimetric Tetraphenylborate Method

Perform a  
Mehlich 2  
Extraction

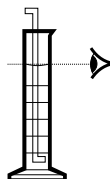


**1.** Obtain a Mehlich 2 extract for the soil sample by performing the Mehlich 2 Extraction procedure in Section 3.

**2.** Using the 1-mL dropper, add 3.0 mL of the sample extract from Step 1 to a 25-mL cylinder.

**3.** Add deionized water to the 21-mL mark on the cylinder. Firmly cap the cylinder with a #3 rubber stopper, and invert to mix.

**4.** Add one Potassium 2 Reagent Powder Pillow and 3 mL of Alkaline EDTA Solution to the cylinder. Cap the cylinder and invert several times to mix. Allow the solution to stand for at least 3 minutes.



Repeat Steps  
6-7 twice

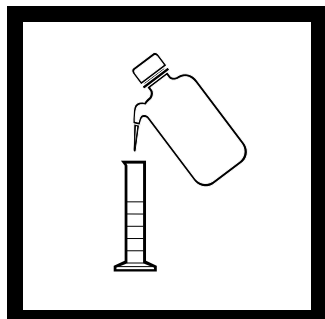
**5.** Add the contents of one Potassium 3 Reagent Powder Pillow. Firmly cap and shake the cylinder vigorously for 10 seconds. Allow the solution to stand for at least 3 minutes but no longer than 10 minutes. A white turbidity will develop.

**6.** While looking straight down into the cylinder, slowly insert the Potassium Dip Stick vertically into the solution until the black dot is no longer visible from above the cylinder.

**7.** Hold the dipstick in that position and rotate the cylinder so you can see the scale on the dipstick. Look across the surface of the sample to the scale on the dipstick. Record the number (in mm) on the dipstick scale where the surface of the sample meets the dipstick scale.

**8.** Repeat Steps 6-7 two more times recording the value each time. Take the average of the three readings. Refer to the potassium conversion table on the following page to determine the level of potassium in the soil.

**POTASSIUM (EXCHANGEABLE) IN SOIL, continued**



9. When analysis is complete, rinse the labware with deionized water.

**POTASSIUM CONVERSION TABLE**

Dipstick Reading mm	mg/L (ppm) Potassium	lbs/A Potassium	Kg/Ha Potassium	meq/100 g Potassium
80	87	174	194	0.22
75	94	188	210	0.24
70	101	202	225	0.26
65	109	218	243	0.28
60	118	236	263	0.30
55	129	258	281	0.33
50	143	286	319	0.37
45	159	318	355	0.41
40	180	360	401	0.46
35	207	414	462	0.53
30	243	486	542	0.62
25	294	588	656	0.75

**REAGENTS**

Description	Cat. No.
Alkaline EDTA Solution, 100 mL	22687-32
Potassium 2 Reagent, Solution Pillows, 25/pkg	14322-98
Potassium 3 Reagent Powder Pillows, 50/pkg	14323-96

**APPARATUS**

Cylinder, Graduated, Polymethylpentene, 25 ml	2172-40
Dropper, Glass, 5/pkg	14197-05
Potassium Dipstick	45700-00
Stopper, Neoprene, Solid, #3	14808-03

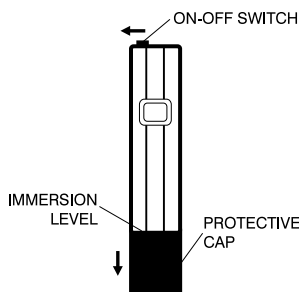
## Salinity (Conductivity) in Soil Electrode Method

### PREPARATION

**A.** Add 50 mL of the Saturated Calcium Sulfate Extraction Solution used for the Calcium Sulfate Extraction procedure in Section 3 to a 50-mL plastic beaker.

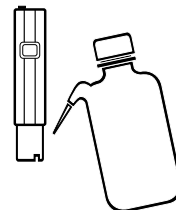
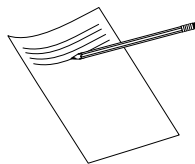
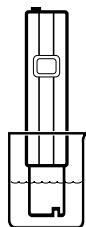
**B** Slide the on/off switch on top of the Pocket Pal Conductivity Tester to on.

**C** Remove the protective cap from the bottom of the instrument. Immerse the electrode tip one inch below the surface of the calcium sulfate extraction solution. If necessary, calibrate the instrument by adjusting the calibration screw near the pocket clip with the trim tool (screwdriver) provided. Adjust the value to 2200  $\mu\text{S}$ . At 2200  $\mu\text{S}$ , the display will read 22 with a small 100 in the upper left hand corner.



### PROCEDURE

#### Perform an Aqueous Extraction



**1.** Obtain an aqueous extract for the soil sample by performing the Aqueous Extraction procedure in Section 3.

**2.** Immerse the tip of the calibrated Pocket Pal Conductivity Tester one inch below the surface of the sample extract prepared in Step 1 and stir gently until the soil is completely suspended.

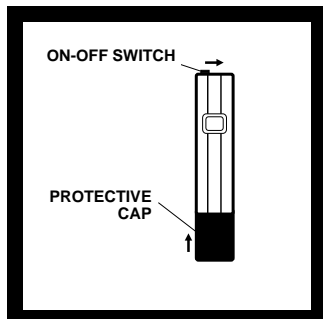
*Note: The range of the Pocket Pal Conductivity Tester is 100-19,900  $\mu\text{S}$ . To obtain the proper value in  $\mu\text{S}/\text{cm}$ , multiply the large reading on Pocket Pal Conductivity Tester by the small value (100) in the upper left hand corner of the display. This gives the conductivity value in  $\mu\text{S}/\text{cm}$ . However, the conductivity of soils should be expressed in  $\text{mS}/\text{cm}$ . Simply divide the large-sized reading by 10 to determine conductivity in  $\text{mS}/\text{cm}$ .*

**3.** When the digital display stabilizes, record the value. Divide the value in the display by 10 to determine the  $\text{mS}/\text{cm}$  of conductivity.

*Note: If the larger display is 199 or greater, the concentration of salt is greater than the capacity of the meter. Dilute the suspension by adding an additional 20 mL of deionized water. Multiplying the final answer by two. If this dilution results in a display reading that is still above capacity, additional 20 mL volumes should be added until a suitable reading is obtained. For every 20 mL added, add two to the multiplication factor (if a total 40 mL is added, multiply by 2; if a total 60 mL is added, multiply by 3 and so on).*

**4.** Rinse the electrode with deionized water, and remove the excess by wiping the tip with a tissue before continuing to the next sample.

*Note: To maintain or improve performance, periodically clean the stainless steel electrode by rinsing it in alcohol.*



**5.** Once the conductivity of each sample has been determined, rinse the electrode with deionized water. Slide the on/off switch to off and cover the electrode with the protective cap before storing.

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**APPARATUS**

<b>Description</b>	<b>Cat. No.</b>
Beaker, 50 mL.....	1080-41
Pocket Pal Conductivity Tester .....	44375-00
Trim Tool .....	18933-00

## Texture Estimation of Soil

Routine soil analysis usually includes an estimation of soil texture. This method is used when exact proportions of sand silt and clay are not needed or when equipment for mechanical analysis of soil is not available. While soil texture estimation requires practice to become highly proficient, satisfactory results can be obtained by using the technique diagramed on the next page and by referring to the modified textural triangle diagramed below. The procedure for estimation of soil texture was developed at Kansas State University by Dr. David Whitney.

The modified version of the textural diagram below omits the rare silt class and combines the loamy sand class with the sandy loam class. Other class boundaries are arranged in a symmetrical fashion that should be easily visualized and remembered.

The modified triangle consists of three tiers based on clay content:

1. the **CLAYS**, those soils high in clay content are strongly cohesive and capable of being shaped into good ribbons.
2. the **CLAY LOAMS** which are intermediate in clay content, cohesiveness, and ribbon formation.
3. the **LOAMS**, or soils low enough in clay content so as to exhibit little or no cohesiveness and form poor or weak ribbons. The **SANDS** do not form ribbons.

The three tiers are each subdivided into three classes:

- a. If silt is highly prominent, the prefix “silt” or “silty” is added to form the categories on the right side of the triangle.
- b. If sand is very prominent, the prefix “sandy” is added to form the categories on the left side of the triangle.
- c. When neither sand nor silt predominates, the intermediate category is used without a prefix, as illustrated by the central portion of the triangle.

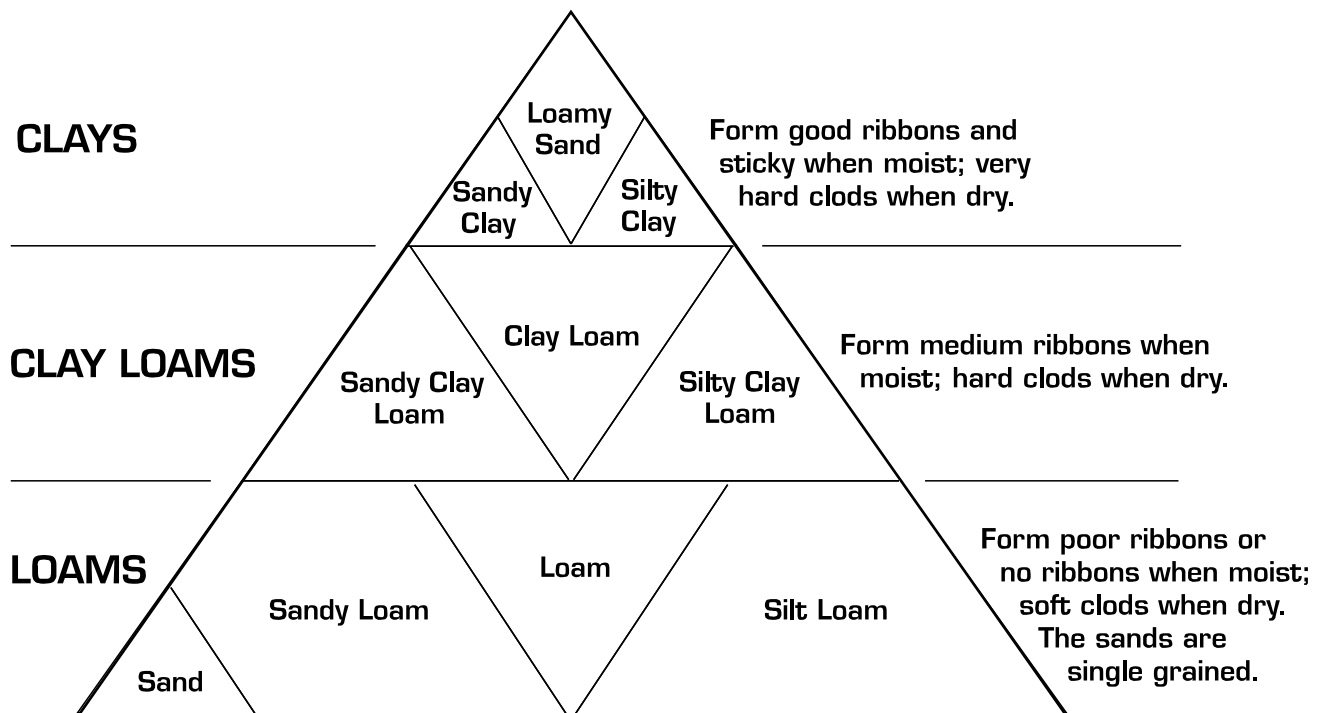
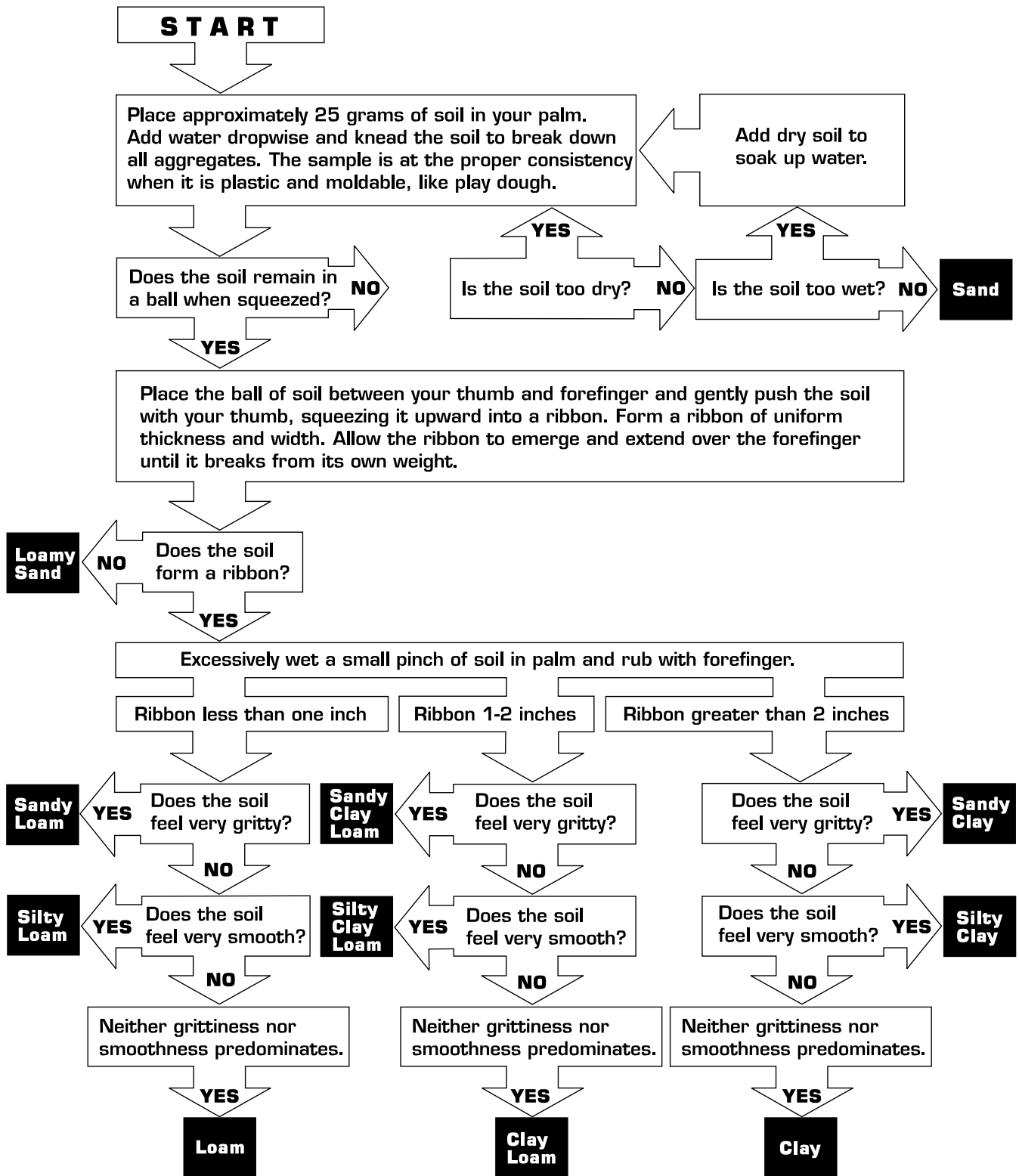


DIAGRAM FOR ESTIMATING SOIL TEXTURE

# ESTIMATING SOIL TEXTURE



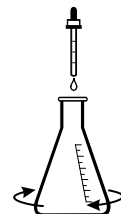
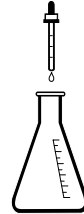
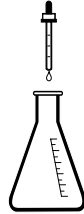
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## Total Exchangeable Acidity in Soil NaOH Titration Method

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### PROCEDURE

**Perform a  
KCl  
Extraction**



**1.** Obtain a potassium chloride extract for the soil sample by performing the Potassium Chloride Extraction procedure in Section 3.

**2.** Add 5-6 drops of phenolphthalein to the erlenmeyer flask containing the sample extract prepared in Step 1. Swirl to mix.

**3.** Titrate the sample by adding 0.075 N NaOH Standard Solution dropwise to the flask while swirling. Keep an accurate count of the number of drops of titrant being added to the solution. Continue titrating until the color begins to change from colorless to light pink.

**4.** As the endpoint is approached, add titrant 1 drop at a time and swirl after each drop. Continue this until a drop of titrant results in a light pink color that does not disappear upon swirling. This is the endpoint of the titration. Record the total number of drops required to reach the endpoint of the titration.

$$\text{Total Exchangeable Acidity (meq/100 g)} = \frac{\text{No. of drops}}{10}$$

**5.** Divide the number of drops of titrant by 10 to determine the meq/100 g of total exchangeable acidity. This value is used to determine the cation exchange capacity of acidic soils as well as the lime requirement of highly acidic and weathered soils.

## TOTAL EXCHANGEABLE ACIDITY, continued

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### CALCULATIONS

Total exchangeable acidity (TEA) is the amount of exchangeable  $H^+$  and  $Al^{3+}$  in the soil, expressed in units of milliequivalents per 100 grams (meq/100 g).

$$TEA = \text{drops of titrant}/10$$

Lime requirement (LR) is the amount of 100% CCE (calcium carbonate equivalents)  $CaCO_3$  needed to raise the soil pH to 6.5 or to 7.0. LR is usually measured in units of tons/acre or tons/hectare. For every 1 meq/100 g of TEA determined by analysis, you would need 1.12 metric tons of 100% CCE  $CaCO_3$  per hectare to neutralize the acid.

$$LR \text{ (tons/acre)} = \frac{TEA}{2}$$

$$LR \text{ (metric tons/Hectare)} = TEA \times 1.12$$

Sample calculations:

$$\begin{aligned} TEA &= 16 \text{ drops of titrant} / 10 = 1.6 \text{ meq}/100 \text{ g} \\ LR \text{ (tons/acre)} &= 1.6 / 2 = 0.8 \text{ tons of } CaCO_3/\text{acre} \\ TEA &= 22 \text{ drops of titrant} / 10 = 2.2 \text{ meq}/100 \text{ g} \\ LR \text{ (metric tons/hectare)} &= 2.2 \times 1.12 = \\ &2.46 \text{ metric tons of } CaCO_3/\text{hectare} \end{aligned}$$

---

### REAGENTS

#### Description

	Cat. No.
Phenolphthalein Indicator Solution, 118 mL .....	162-37
Sodium Hydroxide Titrant, 0.075 N, 118 mL .....	24980-37

### APPARATUS

Flask, Erlenmeyer, Polymethylpentene, 125 ml .....	20898-43
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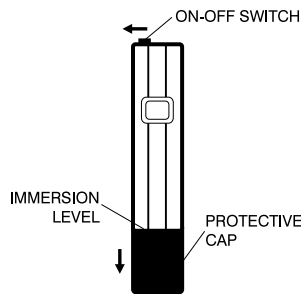


# SECTION 5 IRRIGATION WATER ANALYSIS PROCEDURES

## Conductivity in Irrigation Water Electrode Method

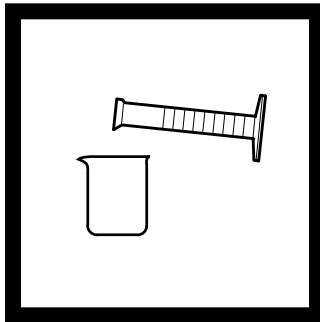
### PREPARATION

- A. Add 50 mL of the saturated Calcium Sulfate Extraction Solution used for the Calcium Sulfate Extraction procedure in Section 3 to a 50-mL plastic beaker.
- B. Slide the on/off switch on top of the Pocket Pal Conductivity Tester to on.

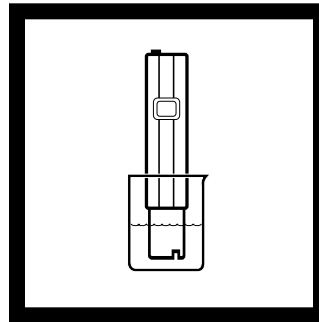


- C. Remove the protective cap from the bottom of the instrument. Immerse the electrode tip one inch below the surface of the calcium sulfate extraction solution. If necessary, calibrate the instrument by adjusting the calibration screw near the pocket clip with the trim tool (screwdriver) provided. Adjust the value to 2200  $\mu\text{S}$ . At 2200  $\mu\text{S}$ , the display will read 22 with a small 100 in the upper left hand corner.

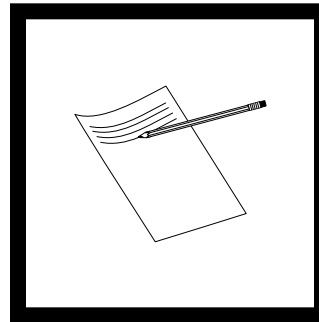
### PROCEDURE



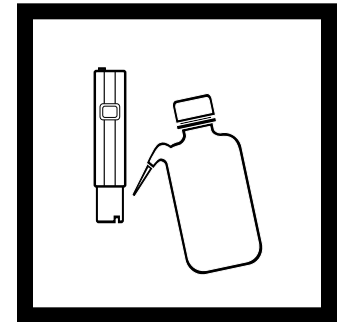
1. Add approximately 30 mL of the sample to a 50-mL plastic beaker.



2. Immerse the tip of the calibrated Conductivity Tester one inch below the surface of the sample and stir gently.

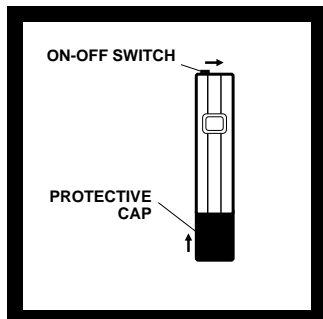


3. When the digital display stabilizes, read and record the display. The correct value in  $\mu\text{S}/\text{cm}$  (or  $\mu\text{mhos}/\text{cm}$ ) is determined by multiplying the reading by the factor displayed in the upper left hand corner.



4. Rinse the electrode with deionized water, and remove the excess by wiping the tip with a tissue before continuing to the next sample.

*Note: To maintain or improve performance, periodically clean the stainless steel electrode by rinsing it in alcohol.*



**5.** Once the conductivity of each sample has been determined, rinse the electrode with deionized water. Slide the on/off switch to off and cover the electrode with the protective cap before storing.

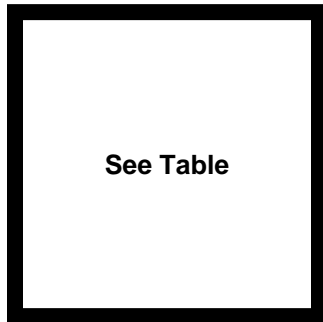
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## APPARATUS

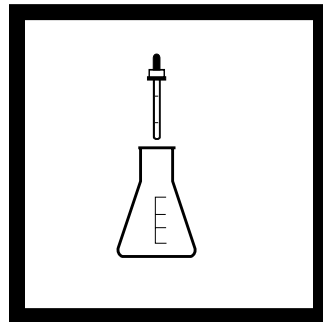
	<b>Cat. No.</b>
Beaker, Polypropylene, 50 ml .....	1080-41
Pocket Pal Conductivity Tester .....	44375-00

# Calcium + Magnesium in Irrigation Water EDTA Titration Method

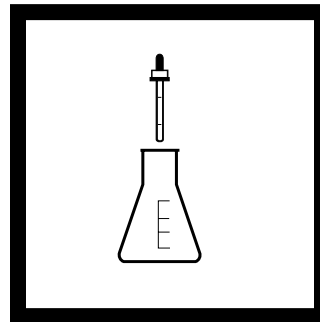
## PROCEDURE



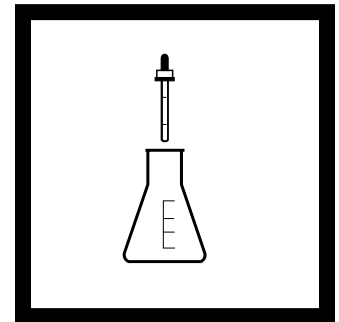
**1.** Using the table below and the conductivity of the analyzed water sample, determine the amount of sample to titrate in this procedure.



**2.** Using either a 1.0-ml or a 2.5-ml dropper, accurately transfer the amount of water determined in the table to a 50-mL erlenmeyer flask. Add about 25 mL deionized water to the flask.



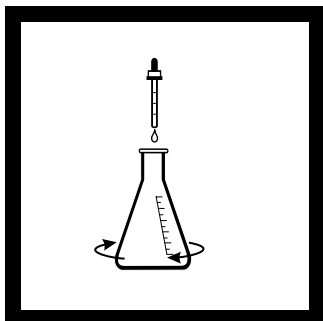
**3.** Add 1.0 mL of Buffer Hardness 1 solution to the flask. Swirl to mix.



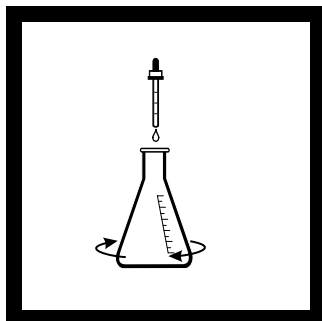
**4.** Add 3 to 4 drops of ManVer Hardness Indicator Solution to the flask and swirl to mix. If calcium and/or magnesium is present, the solution will have a wine red color.

Conductivity $\mu\text{S}/\text{cm}$	mL of Water To Titrate
>2000 mS/cm	1.0 mL
<2000 mS/cm	2.5 mL

# CALCIUM + MAGNESIUM IN IRRIGATION WATER, continued



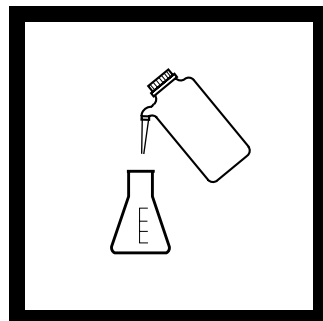
**5.** Titrate the sample by adding 0.0075 N EDTA Standard Solution dropwise to the flask while swirling. Keep an accurate count of the number of drops being added to the solution. Continue titrating until the color begins to change from wine red to violet.



**6.** As the endpoint is approached, add 1 drop of titrant at a time and swirl. Continue this until a drop of titrant no longer results in a visible color change. This is the endpoint of the titration. Record the total number of drops required to reach the endpoint of the titration. The solution will be pure blue.

*Note: If the sample contains high amounts of copper, the solution will reach endpoint without turning pure blue. If this occurs, add drops of titrant until no color change is visible.*

$$\text{Ca + Mg meq/L} = \frac{\text{Drops of Titrant}}{(2 \times \text{mL of sample})}$$



**8.** When analysis is complete, rinse the glassware with deionized water. Shake dry.

**7.** Determine the meq/L of Ca + Mg using the formula above.

**Example:** The conductivity of a water sample was determined to be 1450 S/cm. The analyst titrates 2.5 mL of the irrigation water sample. The total number of drops to reach the endpoint was 50. The meq/L Ca + Mg is calculated as follows:

$$\begin{aligned} \text{meq/L Ca + Mg} &= \\ \frac{50}{2 \times 2.5} &= \\ \frac{50}{5} &= \end{aligned}$$

10 meq/L of Ca + Mg

## REAGENTS

### Description

	Cat. No.
Hardness 1 Buffer, 100 mL .....	424-32
ManVer Hardness Indicator Solution, 100 mL .....	425-32
EDTA Standard Solution, 0.0075 N, 100 mL .....	24981-00

## APPARATUS

Cylinder, Graduated, Polymethylpentene, 25 ml .....	2172-40
Flask, Erlenmeyer, Polymethylpentene, 50 ml .....	20898-41

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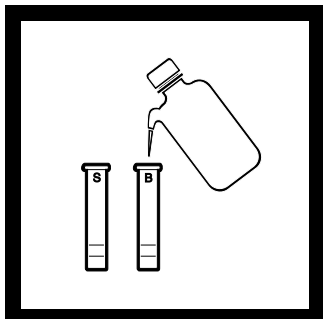
## Nitrate Nitrogen in Irrigation Water (0-50 mg/L) Cadmium Reduction Method

### PREPARATION

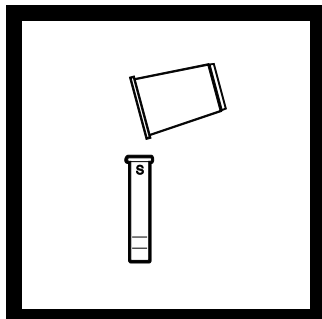
Place the High Range Nitrate Color Disc into the Color Comparator. Make sure it is inserted so the mg/L values are visible through the window of the Color Comparator.

---

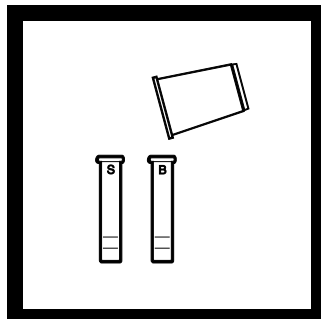
### PROCEDURE



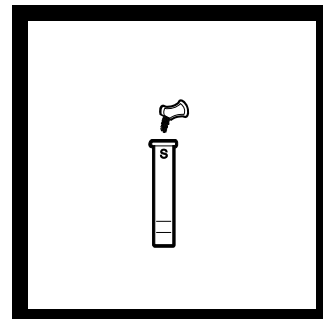
**1.** Label 1 Color Viewing Tube "S" for sample and another Color Viewing Tube "B" for blank. Thoroughly rinse both Color Viewing Tubes with deionized water. Shake the tubes to remove the remaining rinse water.



**2.** Add a small amount of the water sample (about 1/4" deep) to the Color Viewing Tube marked "S". Cap the tube with a rubber stopper and shake it for a few seconds. Discard this solution.



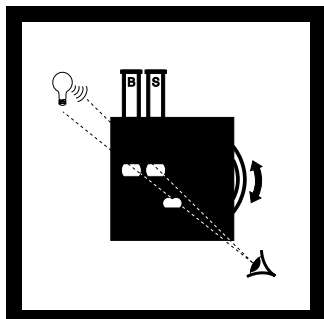
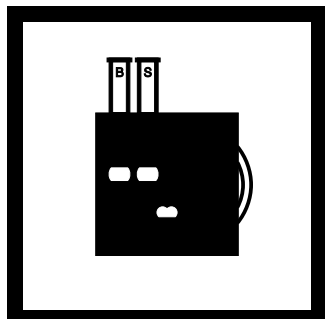
**3.** Add the water sample to both tubes until the meniscus is even with the 5-mL mark on the tubes (bottom of the frosted area).



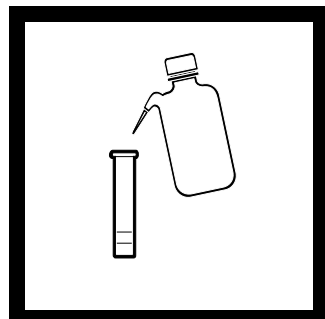
**4.** Add the contents of one NitraVer 5 Powder Pillow to the tube marked "S". Cap and shake the tube vigorously for exactly one minute.

*Note: This kit contains a 15 mg/L nitrate-nitrogen standard so the analyst can learn proper shaking technique and use of the color wheel. It is suggested the analyst practice with the standard until repeated results are within 1 mg/L of each other. The standard should read near 15 mg/L. If the experimental concentration is less than 14 mg/L or greater than 17 mg/L, repeat the procedure until satisfactory results are obtained.*

# NITRATE NITROGEN IN IRRIGATION WATER, continued



**NO<sub>3</sub>-N =**  
**(Average of 3 readings)**



**5.** Immediately place tubes “S” and “B” into the comparator with tube “B” in the outside hole and tube “S” in the inside hole.

**6.** Five minutes after completing Step 5, hold the Color Comparator up to a light source. Rotate the disc until the color in the window for tube “B” matches the color in the window for tube “S”. Record the value in the window. Take two more readings for the sample, rotating the color disc between each reading. Complete all three readings within 10 minutes of completing Step 5.

*Note: Readings before 5 minutes or after 10 minutes will result in an inaccurate value.*

*Note: It is very important that the blank and the sample are viewed under the same lighting conditions.*

**7.** Take the average of the three readings to determine the mg/L NO<sub>3</sub>-N in the sample.

**8.** When analysis is complete, rinse the color viewing tubes with deionized water and store the color disc in the plastic bag provided.

## REAGENTS

### Description

Nitrate Nitrogen, High Range, Color Disc . . . . .	14038-00
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### Cat. No.

## APPARATUS

Color Comparator Box . . . . .	1732-00
Color Viewing Tube with caps, plastic, pk/4. . . . .	46600-04
Nitrate Nitrogen, High Range, Color Disc . . . . .	14038-00

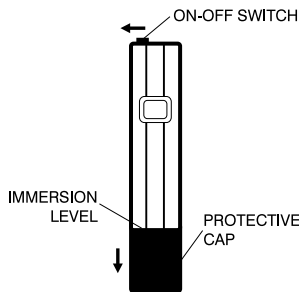
---

## pH in Irrigation Water Electrode Method

### PREPARATION

Calibrate the Pocket Pal pH Tester according to the directions below.

**A.** Prepare a pH 7.00 buffer solution by adding the contents of one pH 7.00 Buffer Powder Pillow to a 50-ml beaker containing 50 mL of water. Swirl the beaker to dissolve the contents.

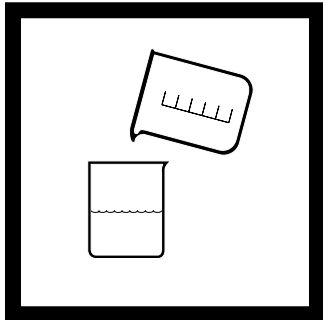


**B.** Slide the on/off switch located on top of the Pocket Pal pH Tester to on.

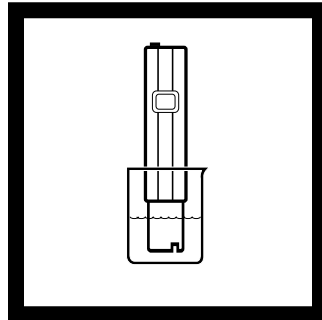
**C.** Remove the protective cap from the bottom of the instrument and immerse the electrode tip one inch below the surface of the solution. If necessary, calibrate the instrument by adjusting the calibration screw near the pocket clip with the trim tool (screwdriver) provided to obtain a reading of 7.0.

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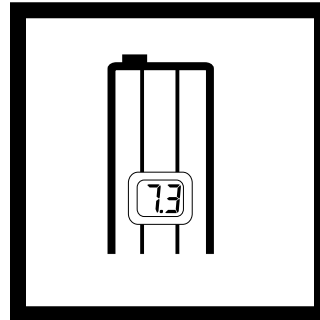
### PROCEDURE



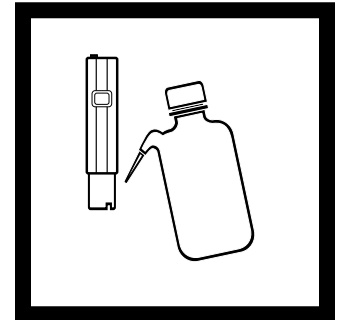
**1.** Add approximately 40 mL of the water sample to a 50-mL plastic beaker.



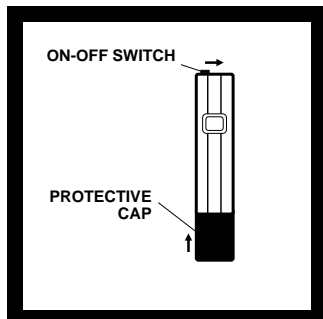
**2.** Immerse the tip of the calibrated Pocket Pal pH Tester one inch below the surface of the sample and stir gently.



**3.** Record the stabilized pH reading to the nearest 0.1 pH unit.



**4.** Rinse the electrode in deionized water. Remove the excess by wiping the tip with a tissue before continuing to the next sample.



**5.** After determining the pH of each sample, rinse the electrode with deionized water. Slide the on/off switch to off and cover the electrode with the protective cap before storing.

---

**REAGENTS**

**Description**

**Cat. No.**

Buffer Powder Pillows, pH 7, 50/pkg ..... 22270-66

**APPARATUS**

Beaker, Polypropylene, 50 ml ..... 1080-41  
 pH Pocket Pal Tester ..... 44350-00



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## Phosphorus in Irrigation Water (0-5 mg/L) PhosVer 3 (Ascorbic Acid) Method

### PREPARATION

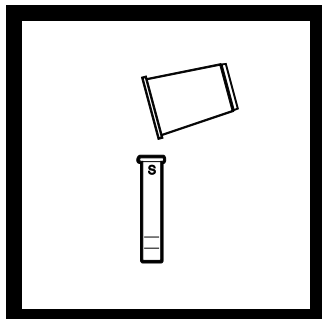
Place the High Range Phosphate Color Disc into the Color Comparator. Make sure it is inserted so the mg/L values are visible through the window of the Color Comparator.

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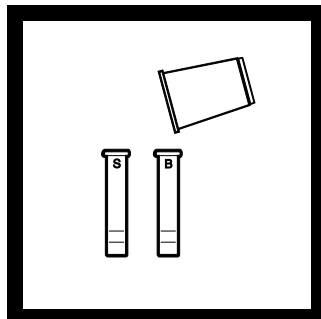
### PROCEDURE



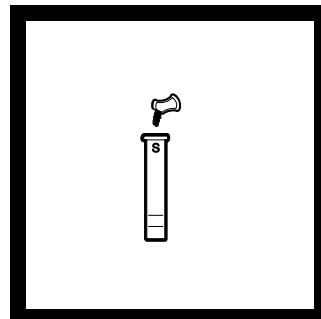
**1.** Label 1 Color Viewing Tube “S” for sample and another Color Viewing Tube “B” for blank. Thoroughly rinse both Color Viewing Tubes with deionized water. Shake the tubes to remove the remaining rinse water.



**2.** Add a small amount of the water sample (about 1/4" deep) to the Color Viewing Tube marked “S”. Cap the tube with a rubber stopper and shake it for a few seconds. Discard this solution.

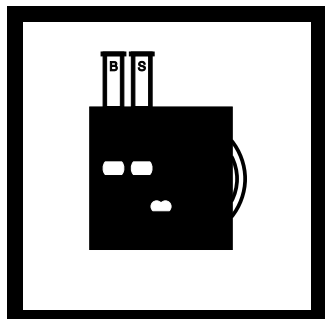


**3.** Add the water sample to both tubes until the meniscus is even with the 5-mL mark on the tubes (bottom of the frosted area).

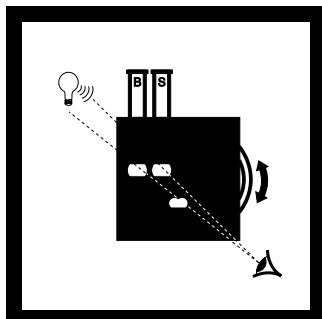


**4.** Add the contents of one PhosVer 3 Powder Pillow to the “S” tube. Cap the tube and shake vigorously for 15 seconds.

# PHOSPHORUS IN IRRIGATION WATER, continued



**5.** Immediately place tubes “S” and “B” into the comparator with tube “B” in the outside hole and tube “S” in the inside hole.



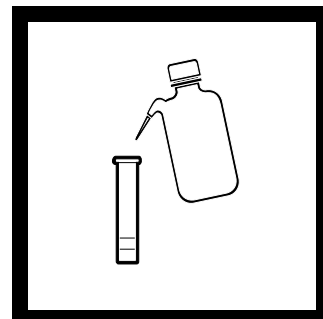
**6.** Three minutes after completing Step 6, hold the Color Comparator up to a light source. Rotate the disc until the color in the window for tube “B” matches the color in the window for tube “S”. Record the value in the window. Take two more readings for the sample, rotating the color disc between each reading. Complete all three readings within 10 minutes of completing Step 6.

*Note: Readings before 3 minutes or after 10 minutes will result in an inaccurate value.*

*Note: It is very important that the blank and the sample are viewed under the same lighting conditions.*

$$\begin{aligned}
 & \text{PO}_4 \text{ (mg/L) =} \\
 & \text{Average of 3 Readings} \\
 & \text{P} = \frac{10}{3.1} \text{ PO}_4 \text{ (mg/L)}
 \end{aligned}$$

**7.** Take the average of the three readings. Divide this value by 10 to obtain the mg/L PO<sub>4</sub> in the sample. To convert the reading to P divide the PO<sub>4</sub> value by 3.1.



**8.** When analysis is complete, rinse the color viewing tubes with deionized water. Shake dry. Store the color disc in the plastic bag provided.

## REAGENTS

### Description

PhosVer 3 Phosphate Reagent Powder Pillows, 100/pkg .....	<b>Cat. No.</b> 2209-99
---	----------------------------

## APPARATUS

Color Comparator Box .....	1732-00
Color Viewing Tube with caps, plastic, pk/4. ....	46600-04
Phosphate, High Range, Color Disc. ....	24898-00

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## Sodium Estimation & Sodium Adsorption Ratio Calculations (Na meq/L) for Irrigation Water

### PROCEDURE

1. Determine the concentration of total soluble salts in meq/L by dividing the conductivity  $\mu\text{S}/\text{cm}$  by 100.

*Note: Refer to the procedure in this section for determining the conductivity of irrigation water.*

2. Determine the Ca + Mg (meq/L) by the EDTA Titration Method.

*Note: Refer to the procedure in this section for the determination of calcium + magnesium in irrigation water.*

3. Subtract the value in step 2 from the value in step 1. This is the estimated sodium in meq/L.

$$\text{Sodium Estimation} = \left( \frac{\text{Conductivity } (\mu\text{S}/\text{cm})}{100} \right) - (\text{Calcium} + \text{Magnesium})$$

### SAMPLE CALCULATIONS

a. A water sample has a conductivity value of  $1250 \mu\text{S}/\text{cm}$ . Calcium + Magnesium meq/L was determined to be 8.6.

b. Sodium Estimation (meq/L) =  $\frac{1250}{100} - 8.6 = 3.9 \text{ meq/L}$

c. SAR =  $\frac{\text{Sodium Estimation (meq/L)}}{\sqrt{\frac{\text{Ca} + \text{Mg (meq/L)}}{2}}} = \frac{3.9}{\sqrt{\frac{8.6}{2}}}$

d. SAR =  $\frac{3.9}{\sqrt{4.3}} = 3.9 / 2.07 = 1.9$

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