

Unit D: pH of Soil

Lesson 1: Identifying the pH Changes in Soil

Student Learning Objectives: Instruction in this lesson should result in the students achieving the following objectives:

1. Identify soil pH.
2. Describe how soil pH is determined.
3. Identify key factors that influence soil pH.
4. Explain how you measure soil pH.

Recommended Teaching Time: 4.5 Hours

Recommended Resources: The following resources may be useful in teaching this lesson

- A PowerPoint has been provided
- http://soil.gsfc.nasa.gov/soil_pH/plant_pH.htm
- <http://soils.usda.gov/sqi/publications/files/indicate.pdf>

List of Equipment, Tools, Supplies, and Facilities:

Writing surface
PowerPoint Projector
PowerPoint Slides
pH Meter
pH test paper/Litmus paper
Soil Samples
8 Household products or food products
Materials needed for making litmus paper with cabbage water
Spoons
Droppers

Terms: The following terms are presented in this lesson (shown in italics and on PowerPoint Slide 2)

- Soil pH
- Acid
- Lime Requirement

Interest Approach: Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

Bring in a cup of orange juice, a bar of soap, a bottle of bleach, and a cup of collected rain water. Ask students about how all of these could relate to soil. Ask if they know what pH is. Then ask them to place the products in order from most acidic to most basic. After they correctly place them in order, explain to them that pH in soil can change from time to time due to rain water and other things found in the soil.

Summary of Content and Teaching Strategies

Objective 1: Identify soil pH.

(PowerPoint Slide 3)

- I. The pH scale measures how acidic or basic a substance is.
 - A. It ranges from 0 to 14.
 1. A pH of 7 is neutral.
 - a. A pH less than 7 is acidic.
 - b. A pH greater than 7 is basic.
 2. Each whole pH value below 7 is ten times more acidic than the next higher value.
 - a. For example a pH of 4 is ten times more acidic than a pH of 5 and 100 times (10 times 10) more acidic than a pH of 6.

(PowerPoint Slide 4)

3. The same holds true for pH values above 7, each of which is ten times more alkaline—another way to say basic—than the next lower whole value.
 - a. For example a pH of 10 is ten times more alkaline than a pH of 9.
4. Pure water is neutral, with a pH of 7.0.
 - a. When chemicals are mixed with water, the mixture can become either acidic or basic.
 - b. Vinegar and lemon juice are acidic substances, while laundry detergents and ammonia are basic.

Give handout TM: D1-1 to students. Have the student's circle where they think their soil at home or at school would be on the scale. Have them discuss with the student sitting next to them and compare answers then discuss with entire class.

Use Lab Sheet LS: D1-1 and complete a lab with the students. Have each product ready for the students to use. Each student will follow the directions on the sheet and continue through each activity. Once they complete the lab, have them clean everything up. Then go through the lab one at a time with the students.

(PowerPoint Slide 5)

- B. **Soil pH** is a measure of the acidity or alkalinity in the soil. It is also called soil reaction.
1. It indicates whether a soil could contain toxic levels of aluminum and manganese, whether it may be low in bases such as calcium and magnesium, and therefore if lime is needed.
 2. The availability of other essential plant nutrients is also affected by pH.
 - a. Therefore, knowing a soil's pH may help in diagnosing nutritional problems of agricultural crops and other plants.
 - b. Soil pH is one of the most important measurements of soil fertility.

(PowerPoint Slide 6)

3. The most common classes of soil pH are:

Extremely acid	3.5 – 4.4
Very strongly acid	4.5 – 5.0
Strongly acid	5.1 – 5.5
Moderately acid	5.6 – 6.0
Slightly acid	6.1 – 6.5
Neutral	6.6 – 7.3
Slightly alkaline	7.4 – 7.8
Moderately alkaline	7.9 – 8.4
Strongly alkaline	8.5 – 9.0

(PowerPoint Slide 7)

4. Soil pH influences the solubility of nutrients.
 - a. It also affects the activity of micro-organisms responsible for breaking down organic matter and most chemical transformations in the soil
 - b. Soil pH thus affects the availability of several plant nutrients.
5. A pH range of 6 to 7 is generally most favorable for plant growth because most plant nutrients are readily available in this range.
 - a. However, some plants have soil pH requirements above or below this range.

(PowerPoint Slide 8)

6. Soils that have a pH below 5.5 generally have a low availability of calcium, magnesium, and phosphorus. At these low pH's the solubility of aluminum, iron, and boron is high; and low for molybdenum.
7. At pH 7.8 or more, calcium and magnesium are abundant. Molybdenum is also available if it is present in the soil minerals. High pH soils may have an inadequate availability of iron, manganese, copper, zinc, and especially of phosphorus and boron.
8. The pH of a soil should always be tested before making management decisions that depend on the soil pH.

Objective 2: Describe how soil pH is determined.

(PowerPoint Slide 9)

- II. pH is determined by the concentration of hydrogen (H^+) ions and hydroxyl ions (OH^-) in the soil solution.

- A. A sample of pure water has an equal number of H₊ and OH⁻ and is neutral.
- B. An **acid** is a substance that releases hydrogen ions. When saturated with H₊, a soil behaves as a weak acid. The more H₊ held on the exchange complex, the greater the soils acidity.
- C. Soil pH measures H₊ activity and is expressed in logarithmic terms.
- D. The practical significance of the logarithmic relationship is that each unit change in soil pH means a ten-fold change in the amount of acidity or alkalinity.
- E. A soil with a pH of 6.0 has 10 times as much active H₊ as one with a pH of 7.0.

Objective 3: Identify key factors that influence soil pH.

(PowerPoint Slide 10)

III. Several factors influence soil pH.

- A. Soil organic matter is continuously being decomposed by microorganisms into organic acids, carbon dioxide, and water, forming carbonic acid. Carbonic acid reacts with Ca and Mg carbonates in the soil to form more soluble bicarbonates, which are leached away, leaving the soil more acid.
- B. Soils developed from parent material of basic rocks generally have higher pHs than those formed from acid rocks.
- C. As water from rainfall passes through the soil, basic nutrients such as calcium and magnesium are leached. They are replaced by acidic elements including aluminum, hydrogen, and manganese. Soils formed under high rainfall conditions are more acidic than those formed under arid conditions.

(PowerPoint Slide 11)

- D. Soils formed under forest vegetation tend to be more acidic than those developed under grasslands
- E. Soils often become more acidic when crops are harvested because bases are removed. Legumes generally contain higher levels of bases than grasses. Legumes also release H₊ ions into their rhizosphere when actively fixing atmospheric N.
- F. Except in low rainfall areas, acidity generally increases with depth, so the loss of topsoil by erosion can lead to a more acid pH in the plow layer. The reason is that more subsoil is included in the plow layer.

(PowerPoint Slide 12)

- G. Nitrogen from fertilizer, organic matter, manure, and legume N fixation produces acidity. Nitrogen fertilization speeds up the rate at which acidity develops. At lower N rates, acidification rate is slow, but is accelerated as N fertilizer rates increase.
- H. The overall effect of submergence is an increase of pH in acid soils and decrease in basic soils. Regardless of the their original pH values, most soils reach pHs of 6.5 to 7.2 within one month after flooding, and remain at that level until dried.

Before you begin Objective 3, put the students into groups of 3 and have them develop a list of factors they think would influence the pH of a soil. See how many they can come up with. Once they complete their list, make one large list on the board as a class and discuss their list. Compare the list to what is discussed in the lesson plan and on the PowerPoint Slides 10-12.

Objective 4: Explain how you measure soil pH.

(PowerPoint Slide 13)

IV. Soil pH Determination

- A. One method to determine soil pH is by using a pH indicator dye kit. It is easy to use and gives a suitable pH value for most soils.
 1. The indicator dye is added to the soil in the spot plate until it is saturated. The solution is stirred using a small spatula.
 - a. The solution will change color depending on the soil pH.
 - b. The solution color is compared to a color card that has been calibrated to various pH readings.
 - c. Indicators are frequently used in the field to make a rapid pH determination and must be used by a trained hand to avoid major error.

(PowerPoint Slide 14) shows a picture of a pH indicator dye kit.

(PowerPoint Slide 15)

- B. The more accurate and widely used method is the soil pH meter used in soil testing laboratories.
 1. The pH meter is an electronic device that can be hooked to a pH sensitive electrode. When the electrode is immersed in a soil solution the pH meter will indicate the pH of the soil.
 2. Measurement of soil pH is very important - but in no way it is easy.
 - a. Soil can be dry, and the pH electrode needs to be immersed to work.
 - b. pH electrodes are very fragile so they can't be hammered into the ground.

(PowerPoint Slide 16)

3. A widely accepted method is to take a sample of the soil, crush any clumps, and close it in a jar filled with distilled water.
 - a. After some vigorous shaking sample should be left for 5 to 10 minutes to let all soluble substances to dissolve and to let all hard parts to sediment.
 - b. Then pH of the solution above sediment is measured in a standard way and called "soil pH".
 - c. When pH is measured, only active acidity in the soil water is determined. Potential acidity not found in soil water, which can be held by the soil, clay, and organic matter, must also be considered.

(PowerPoint Slide 17) Picture of a soil pH meter.

(PowerPoint Slide 18)

- V. **Lime requirement** is the amount of agricultural limestone needed to establish the desired pH range for the cropping system being used.
- A. Lime raises the pH of soil, i.e. makes it less acidic.
 - 1. Lime is added to "sweeten" the soil.
 - 2. In areas where the soil is sandy, lime is often added to make the soil less acidic for crops like corn and beans.
 - B. The most common liming materials are calcitic or dolomitic agricultural limestone.
 - 1. These are natural products made by finely grinding natural limestone.
 - 2. Since natural limestone is relatively insoluble in water, agricultural limestone must be very finely ground so it can be thoroughly mixed with the soil and allowed to react with the soil's acidity.

(PowerPoint Slide 19)

- 3. Other soil liming materials that may be used but are not as effective include:
 - a. Wood Stove ashes
 - b. Fire Place ashes
 - c. Boiler Wood ashes
- C. Do NOT over-lime!
 - 1. Lime adjusts soil chemistry, it is not a fertilizer.
 - 2. A little too much can raise pH to undesirable levels and keep it there, causing serious management problems.
 - 3. Make certain you know how much lime is needed, then apply it over a number of seasons until your soil is back in balance.

(PowerPoint Slide 20)

- VI. Aluminum Sulfate can be used to lower the pH, to make it more acidic.
- A. This would be used in soils that are basic and you are trying to grow Azaleas, Rhododendrons, Junipers, Hydrangeas, Pines and other acid loving plants.

Give a demonstration on how to measure soil pH using a pH indicator dye kit and/or a soil pH meter. Have different students come up one at a time and assist you in doing this. Do this several different times with at least three different soil samples. This will give students a range of what the different soil pH's could be. It will also allow more students to help you. Check with a local fertilizer or extension specialist if you do not have a pH indicator dye kit or a soil pH meter. Also ask them to explain liming requirements and how much is needed for soils in Afghanistan.

Review/Summary: Use the student learning objectives to summarize the lesson.

Student responses to the questions on **PowerPoint Slide 21** can be used to determine which objectives need to be reviewed.

Application: If you have access to a pH indicator dye kit or a soil pH meter, have students bring in samples of soil from their gardens and or farms and determine the pH of their soils. Have a local fertilizer specialist or extension educator visit the class and explain/demonstrate how to properly use a pH meter using soil from the school farm or soils from the local area.

Evaluation: Evaluation should focus on student achievement of this lesson's objectives. A sample test has been provided.

Answers to Sample Test:

Part One: Matching

1=c, 2=b, 3=a, 4=b, 5=a, 6=c

Part Two: Completion

1. Lime
2. Neutral
3. Hydrogen and Hydroxyl
4. Forest

Sample Test

Name_____

Test

Unit D Lesson 1: Identifying the pH Changes in Soil

Part One: Matching

Instructions. Match the term with the correct response. Write the letter of the term by the definition.

- a. Soil pH
- b. Acid
- c. Lime Requirement

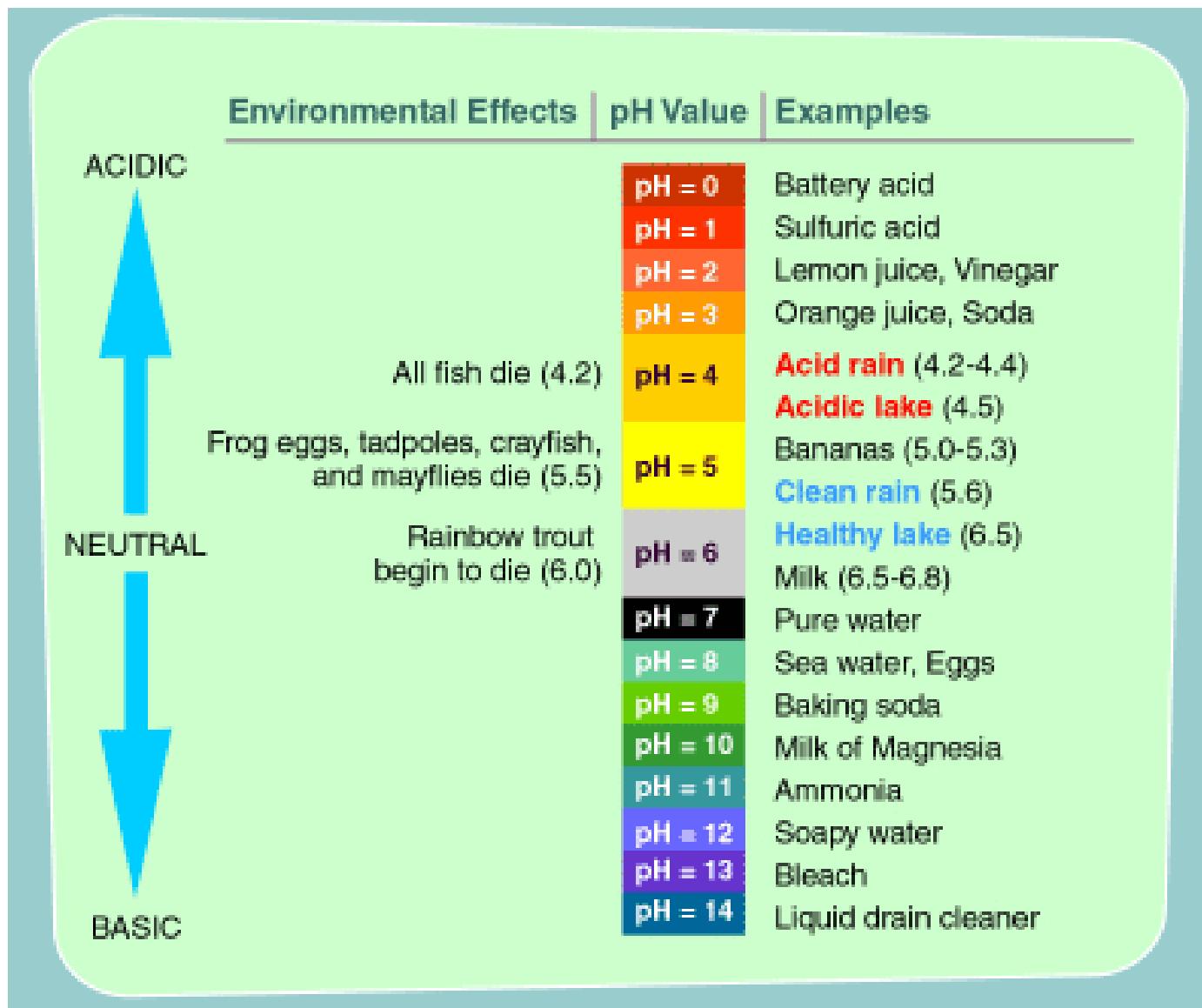
- _____ 1. What is needed to make an acidic soil more basic.
- _____ 2. A pH of less than 7.
- _____ 3. This identifies whether the soil is a base or acid.
- _____ 4. Soil pH similar to citric acid.
- _____ 5. This can be changed due to natural rainwater over time.
- _____ 6. The amount of Base used to change pH of a soil.

Part Two: Completion

Instructions. Complete the following statements.

- 1. _____ adjusts soil chemistry, it is not a fertilizer.
- 2. _____ pH is 7.0.
- 3. _____ ions and _____ ions determine soil pH
- 4. Soils formed under _____ vegetation tend to be more acidic.

pH Scale



LS: D1-1

Name _____

Lab Sheet

Testing Common Substances for pH

Objective:

Investigate the importance of soil pH and its relevance to plant growth.

Equipment:

6–8 household products/food products (Lemon Juice, Baking Soda, Vinegar, Soap, Ammonia, Bleach, Lemon, Orange, Milk, Apple, Tonic Water, etc.)

Droppers

Spoons

Paper plates

Litmus paper (If you cannot buy litmus paper you can make some using the directions on TM: D1-2.

Procedure:

1. Set up the products on a table.
2. Take a small sample from each product and rub on litmus paper. The color change will indicate whether the product is acid or alkaline.
3. Determine whether the product is acid or alkaline.
4. Record the results on a data sheet/chart when done.
5. Compare the pH of the tested products to common soil pH level requirements of plants.

LS: D1-1

TESTING COMMON SUBSTANCES FOR PH—DATA SHEET

Sample #	Test Observation	Comments

TM: D1-2



pH Paper

pH paper is one of the ways to indicate pH. You can buy pH paper or you can make your own:

1. MAKE cabbage water.
2. ADD drops of the cabbage water to coffee filter strips and BAKE the strips dry.
3. Pink indicates acid; green or blue indicates base.

Cabbage Water



Red Cabbage water is an indicator of pH.

1. CHOP one large red cabbage into small pieces.
Note: Blackberries, red onions, or even hibiscus flowers can be used as a substitute.

2. SIMMER the cabbage pieces until the water turns a deep shade of purple.
3. ALLOW the water to cool.
4. REFRIGERATE when not in use.