Soil pH

By Diedre Young MAT, Soybean Science Challenge

Photo courtesy of Unsplash

Arkansas NGSS Standards Suggestions:

Integrated Biology:

Topic 6: Life and Earth's Systems

BI-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [AR Clarification Statement: This PE is partially addressed in this course. Emphasis is on the properties of water and the water cycle.

BI6-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. [AR Clarification Statement: Proposed problems could include increases in pollution, greenhouse gases, water runoff and soil erosion, coastal erosion, and loss of wetlands.]

BI6-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. [AR Clarification Statement: Solutions could include those designed by students or identified from scientific studies.]

Science and Engineering Practices:

Planning and Carrying out Investigations: (BI-ESS2-5)
Designing Solutions

- (BI6-ETS1-2)
- (BI6-ETS1-3)

Disciplinary Core Ideas:

ESS2.C: The Roles of Water in Earth's Surface Processes
(BI-ESS2-5)
ETS1.B: Developing Possible Solutions
(BI6-ETS1-3)
ETS1.C: Optimizing the Design Solution
(BI6-ETS1-2)

CrosscuttingConcepts:

Structure and Function:
(BI-ESS2-5)

Influence of Engineering, Technology, and Science on Society and the Natural World:
(BI-ESS2-2, BI6-ETS1-3)

Connections to the Arkansas Disciplinary Literacy Standards:
RST.11-12.7-8-9

Connections to the Arkansas Mathematics Standards:
MP.2, MP.4, HSN.Q.A.3

Soil pH

Integrated Chemistry:

Topic 1: Matter and Chemical Reactions

CI-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).

CI1-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. [AR Clarification Statement: Examples of real-world problems could include wastewater treatment, production of biofuels, and the impact of heavy metals or phosphate pollutants on the environment.]

Science and Engineering Practices:

Planning and Carrying Out Investigations (CI-ESS2-5)

Constructing Explanations and Designing Solutions: (CI-1-ETS1-2)

Disciplinary Core Ideas:

ESS2.C: The Roles of Water in Earth's Surface Processes (CI-ESS2-5)

ETS1.C: Optimizing the Design Solution (CI-1-ETS1-2)

Crosscutting Concepts:

Structure and Function (CI-ESS2-5)

Connections to the Arkansas Disciplinary Literacy Standards:

WHST.9-12.7

Connections to the Arkansas Mathematics Standards:

MP.4, HSN.Q.A.3

Soil pH

Chemistry II:

Topic 3 Reactions

CII-PS3-3AR: Plan and carry out an investigation to predict the outcome of a chemical reaction based on patterns of chemical properties. [Clarification Statement: Examples of various reaction types could include acid base, precipitation, or redox. Examples of patterns could include the use of solubility rules, activity series, or titrations.]

CII3-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. [AR Clarification Statement: Examples could include the effects of concentration of solutions on the freezing/boiling point (melting of ice on roadways).]

Science and Engineering Practices:

Asking Questions and Defining Problems (CII3-ETS1-3)

Disciplinary Core Ideas:

PS1.B: Chemical Reactions (CII-PS3-3AR)

ETS1.B: Developing Possible Solutions (CII3-ETS1-3)

Crosscutting Concepts:

Patterns (CII-PS3-3AR)

Interdependence of Science, Engineering, and Technology (CII3-ETS1-3)

Influence of Engineering, Technology, and Science on Society and the Natural World (CII3-ETS1-3)

Connections to the Arkansas Disciplinary Literacy Standards:

WHST.9-12.7

Connections to the Arkansas English Language Arts Standards:

SL.11-12.4-5

Soil pH

Connections to the Arkansas Mathematics Standards:

MP.4, HSN.Q.A.3

Objective: The students will understand that pH of soil is based on several chemical and biological factors. The proper soil pH for each plant species is essential to know for proper growth for that plant. Soil pH can be affected by manmade environmental factors such as pollution, acid rain, and water runoff.

Assessment: Students will be given a form at the end of the period that covers what was learned in the mini lab. A form example will be at the end of the lesson.

Key Points: pH, water impact on soil pH, chemical properties of acid-base, effects of pH on soil and plants.

Materials: Various soil samples*, measuring cups, plastic 8 oz cups, spoons, distilled water, pH measuring devices (this could be pH meters, pH paper, or liquid pH indicators). **consider asking students to bring samples of soil from where they live the day before this lesson.*

Preparation: About 10-20 minutes depending on class size.

Time duration: One class period.

Elicit: Do a KWL chart about what students know about soil pH and its importance to plants.

Engage: Each of these videos are approximately 3-5 minutes. You can pick and choose.

https://www.youtube.com/watch?v=BouMFj9acX0 This video is about pH and nutrient availability in soil.

https://www.youtube.com/watch?v=zQowljL8e5E This video is about basic pH in soil.

https://www.youtube.com/watch?v=HmEyymGXOfI This video is about cation-anion exchange in soil.

Explain: Students should now have an idea that soil pH is important to plants. Soil pH or soil reaction is an indication of the acidity or alkalinity of soil and is measured in pH units. Soil pH is defined as the negative logarithm of the hydrogen ion concentration. The pH scale goes from 0 to 14 with pH 7 as the neutral point. As the amount of hydrogen ions in the soil increases, the soil pH decreases thus becoming more acidic. From pH 7 to 0 the soil is increasingly more acidic and from pH 7 to 14 the soil is increasingly more alkaline or basic.

Soil pH

Descriptive terms commonly associated with certain ranges in soil pH are:

- Extremely acid: < than 4.5; lemon=2.5; vinegar=3.0; stomach acid=2.0; soda=2.0–4.0
- Very strongly acid: 4.5–5.0; beer=4.5–5.0; tomatoes=4.5
- Strongly acid: 5.1–5.5; carrots=5.0; asparagus=5.5; boric acid=5.2; cabbage=5.3
- Moderately acid: 5.6–6.0; potatoes=5.6
- Slightly acid: 6.1–6.5; salmon=6.2; cow's milk=6.5
- Neutral: 6.6–7.3; saliva=6.6–7.3; blood=7.3; shrimp=7.0
- Slightly alkaline: 7.4–7.8; eggs=7.6–7.8
- Moderately alkaline: 7.9–8.4; sea water=8.2; sodium bicarbonate=8.4
- Strongly alkaline: 8.5–9.0; borax=9.0
- Very strongly alkaline: > than 9.1; milk of magnesia=10.5, ammonia=11.1; lime=12.0

The effect of soil pH is great on the solubility of minerals or nutrients. Fourteen of the seventeen essential plant nutrients are obtained from the soil. Before a nutrient can be used by plants it must be dissolved in the soil solution. Most minerals and nutrients are more soluble or available in acid soils than in neutral or slightly alkaline soils.

Phosphorus is never readily soluble in the soil but is most available in soil with a pH range centered around 6.5. Extremely and strongly acid soils (pH 4.0-5.0) can have high concentrations of soluble aluminum, iron and manganese which may be toxic to the growth of some plants. A pH range of approximately 6 to 7 promotes the readiest availability of plant nutrients.

The soil pH can also influence plant growth by its effect on activity of beneficial microorganisms. Bacteria that decompose organic matter are hindered in strong acid soils. This prevents organic matter from breaking down, resulting in an accumulation of organic matter and the tie up of nutrients, particularly nitrogen, that are held in the organic matter.

Soils tend to become acidic because of: (1) rainwater leaching away basic ions (calcium, magnesium, potassium, and sodium); (2) carbon dioxide from decomposing organic matter and root respiration dissolving in soil water to form a weak organic acid; (3) formation of strong organic and inorganic acids, such as nitric and sulfuric acid, from decaying organic matter and oxidation of ammonium and sulfur fertilizers. Strongly acid soils are usually the result of the action of these strong organic and inorganic acids.

Therefore, the correct soil pH levels are essential for growing plants, and plants vary as to their soil pH needs.

Elaborate: Students will be placed in groups of four and will be given four samples of soil to test for pH (these can include the soils students bring from home). Explain to the students that they will be given four 'hypothetical plants' that will need to be planted and they must determine which soil would be best for each plant. Some plants will require a pH different from what the soil provides, so students will also want to discuss (and research) what must to be done to each soil to grow a particular plant. Strongly consider giving four different plants to each group so everyone will have to do their own work.

The Experiment:

Each group of four students will be given a measuring cup, four spoons, four 8 oz plastic cups, four soil samples, 16 oz of distilled water, and pH measuring material. Students must label the four cups with the soil they are putting in them.

- Each cup will get 2 oz of soil and 2 oz of distilled water.
- Have students mix each cup and then let the soil settle out.
- Have students then do a pH measurement on the water (twice) and have each group decide (from the attached plant-pH sheet) which soil is best for the plants they have.

The results:

- Students will discuss in their group how to alter the soil's pH to meet each plant's requirement.
- Each student fills out a form individually with their answers to be submitted for grading. These can be turned in at the end of the period or the next day.

Evaluate: Students will hand in their 'lab sheet' for evaluation.

Extend: Consider turning this into a multi-day lab and have students plant seeds that would fit their soil pH type and see what happens. Students can adjust the soil pH and see the results.

Have a local botanist come in and speak about the importance of pH and nutrient uptake of plants.

Have an agricultural chemist come in and speak about soil chemistry.

Soil pH Lab Form

What is the pH of your four soils?

1).

2).

3).

4).

What are the four 'plants' you have been given and note which soil # and pH would best go with each plant. ***Be sure to note the pH range each plant can grow in.***

A).

B).

C).

D).

Do any of the plants need changes in the soil pH to grow? If yes, what would need to be done to the soil before planting your plant?

A).

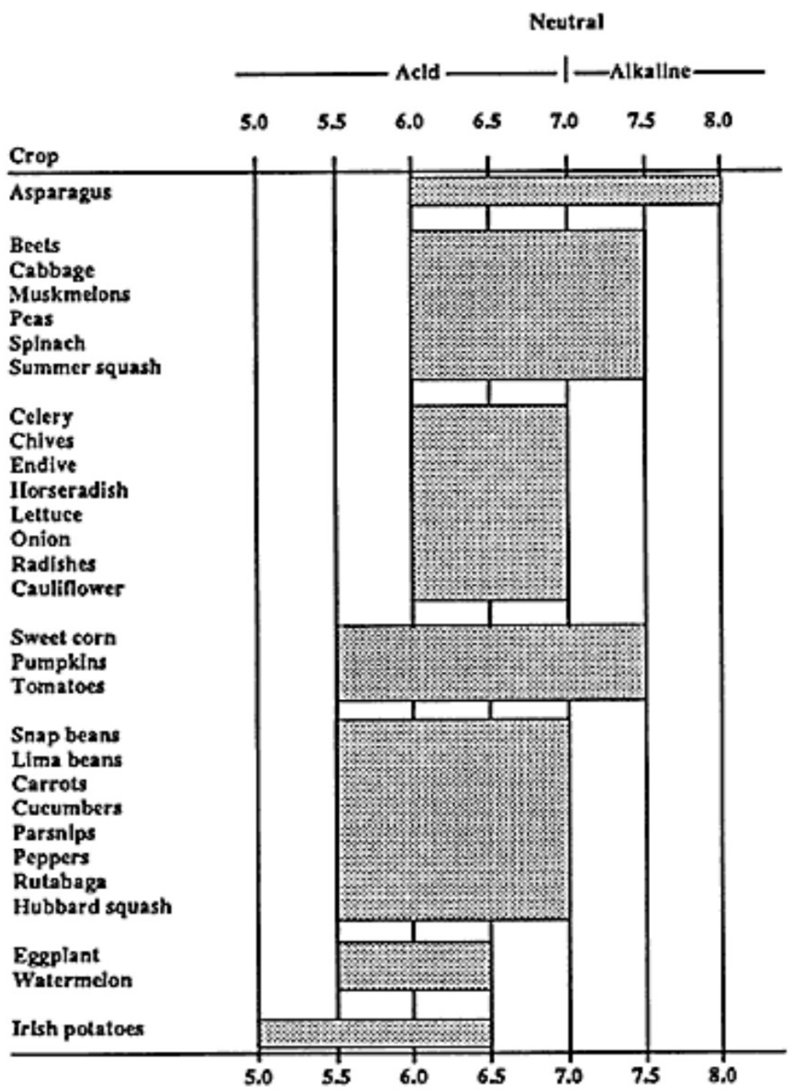
B).

C).

D).

Plant Options

**You will notice there is quite a pH range plants can grow in.
So, this should be an easy decision for the students.**



Acidic Soils: 4.5-6.7 pH

Carrots
Potatoes
Tomatoes
Roses
Eggplant
Endive
Sweet potato
Radishes
Onions
spinach

Neutral Soils: 6.8-7.3 pH

Asparagus
Cabbage
Okra
Parsley
Peppers
Ferns
Pumpkins
Broccoli
Cauliflower
Lettuce

Alkaline Soils: 7.5+

Beans
Lavender
Celery
Beets
Garlic
Honeysuckle
Lily of the Valley
Artichoke
Arugula Lettuce
Peas