From Quarry To Crop:
Growing More with Aglime

Introduction:

Students will experience one of the ways our food requires both farming and mining while growing their knowledge in life science, physical science and Earth science. Students will create different types of soil conditions, plant seeds and observe growth under each condition to assess the importance of pH to crop growth.

Expected Learning Outcomes:

Completion of this experiment will provide opportunities for students to:

- Recognize and understand the processes of planting and culturing plants.
- Observe the importance of soil conditions including acid/base conditions and how to manage these.
- Observe the impact of variations in the pH (acid or alkaline character) of the soil on seed germination and plant growth.
- Learn how agricultural limestone, a.k.a. aglime, a mined product, is used to increase the pH of soils.
- Observe and understand the importance of water in the soil, i.e., the soil solution.
- Observe and analyze the difference in germination times for different plants' seeds and growth rates as these are influenced by soil pH.
- Observe the chemical reaction as the "aglime" (antacid tablet) reacts with the vinegar.
- Recognize the importance of mining and mined materials in our daily lives, from mines, to farms to pharmaceuticals, to the food on our tables.

Materials, supplies, and equipment needed:

- Personal protective equipment (PPE) to include at least eye protection and gloves.
- An empty egg carton, extra-large egg size recommended.
- Potting soil, from any lawn and garden store or hardware store.
- Distilled vinegar, from the grocery store shelf.
- Antacid tablets. Tums® is the recommended brand due to the fact that its manufacturing process requires that the limestone be more finely ground than store-brand products; hence, it reacts better in the soil and speeds up the outcomes of your experiment. Antacid tablets are used to substitute for the mined product agricultural lime, commonly called aglime.
- If available, a mortar and pestle to grind the antacid tablets. A small hammer and a heavy-duty plastic sandwich bag may be used. The hammer and bag process actually replicates the quarry

operator's final crushing mechanism, a hammer mill crusher, to reduce the gravel-size crushed limestone pieces to aglime-sized pieces.

- Spatula or spoon to handle the soil and crushed antacid tablets.
- Stirring rod or the handle of a teaspoon for stirring.
- A liquid measuring device – small disposable medicine dose cups or measuring spoons will work – to measure 3-10 milliliter volumes of liquids.
- pH paper or, preferably, a digital pH meter.
- Seeds – Annual ryegrass is recommended. Adding tomato and bean seeds to the planting will increase the variation in the outcomes in time of germination and emergence of the seeds' initial growth shoots as well as the growth habits of the monocot and dicot plants.
- Device to use to photograph the experiment for your documentation.
- See the instructional video that shows these items and the experimental procedure in action at www.MineralsEducationCoalition.org/esw.

Procedure:

1. Remove the top from the egg carton and place it under the bottom part of the egg carton to strengthen the "planting cells" in the bottom of the egg carton.
2. Fill each cell in the egg carton with potting soil and press it down a bit to compact it. Add 5-10 ml of water to each cell to moisten the potting soil, unless it is moist as it comes from the delivery bag.
3. Follow the diagram for the soil treatments:

Cells 1 and 2: to each, add 10 ml of vinegar to acidify the soil.
Cells 3 and 4: to each, add 10 ml of vinegar and one crushed antacid tablet, i.e., aglime.
Cells 5 and 6: to each, add 10 ml of vinegar and two crushed antacid tablets, i.e., aglime.
Cells 7 and 8: add nothing; these are the control cells.
Cells 9 and 10: to each, add one crushed antacid tablet, i.e. aglime, to make the soil basic.
Cells 11 and 12: to each, add two crushed antacid tablets, i.e. aglime, to make the soil more basic.

4. Gently mix the soil, water, and additives together in all cells with stirring rod or a teaspoon handle.

5. Once the soil in the cells have been watered with 5-10 ml of water each, and had a day or two for the chemical reactions to come to an end point, the pH of each cell can be measured and recorded. The actual pH will vary with the potting soil used, but the use of vinegar and antacid will give a range sufficient to see the effects of pH values that differ from the optimal range for growing the suggested plants--a pH of 6.5 to 7.0.
6. Once the chemical reactions have reached end points in 2-3 days, the cells should be planted following this plan:
   - Plant all odd numbered cells with all annual ryegrass seeds, about 20 seeds per cell.
   - Plant the even numbered cells with two or three bean seeds per cell and two or three tomato seeds per cell or any other plant seeds available. All seeds should be covered with more potting soil to a depth of 2.5 times the seed's average diameter.
7. The planted cells should then be watered with 5-10 ml of water per cell, depending on how dry they have become.
8. Place the egg carton planter where it is exposed to either sunlight or the light of a growth lamp.
9. Data Collection and Analysis—Daily:
   - Begin recording written observations and photographs when the cells are being filled with soil, and record every step or action taken after that.
   - Continue to make observations daily for at least three weeks as the cells are watered.
   - Analyze your data with respect to:
     - The day the first plant growth shows in the cells;
     - The daily rate of growth of the plants;
     - The color and hardiness of the plants;
     - Any other facts that can be observed, qualified and/or quantified, and recorded for later reference and analysis.
   - Represent your growth data in a graphical display.

<u>Questions for thought:</u>

1. What visible events occurred when the "aglime" (ground antacid tablets) was added to each cell, water was added, and the soil "solution" was mixed with the stirring rod? Why?
2. Search for some information about the reaction of vinegar and limestone – what is this kind of chemical reaction called and what pH change is associated with this reaction?
3. Which cells produced visible plant growth first? Why?
4. How did the emergence and appearance of these new plants compare? Describe these factors.
5. In what order did the different seeds produce growth of an initial plant stock? (This question assumes that seeds other than annual ryegrass were also planted.)
6. Which cells, if any, did not produce any plant growth? Why? What is different between the soils in these cells?
7. Which cells produced the most rapid and tallest plant growth? Why?
8. Consider these outcomes in a farmer's field. Support an argument for how important you think the pH of the soil is to produce the most plant growth and crop yield?
9. Research how the chemical makeup and properties of aglime influence its effectiveness?

10. Where can a farmer in your town purchase aglime? Hint: Look for limestone quarries in your area.
11. Interview a farmer and a quarry operator about the importance of aglime and how it is produced. Find out how aglime is applied to the farmer's field, and how many crop years an aglime application usually lasts for a farmer's field.
12. If you live in an area where soils are alkaline, what mined product is produced and applied to farmers' fields to reduce the pH to the 6.5 to 7.0 range for productive plant growth?
13. How does the production of this mined product (in question 15) compare with the production of aglime? How do the costs to the farmer compare?
14. Think of additional examples of the importance of mining to food production.
15. Think of other examples where other mined products used in your daily life.

Additional Activity:

View the video about aglime at www.MineralsEducationCoalition.org/esw.

For Further Thought and Exploration:

A. What part does nature's hydrologic cycle play in making the addition of aglime to a farmer's field effective in increasing the pH of the soil? What action was taken in conducting your experiment that replicated this on the farmer's field? Explain how your actions in this experiment are like natural events.
B. Check the agricultural literature and learn how the farmer mixes the aglime with the soil in a field. What part of your experiment replicated this farm field activity?
C. What is the chemical makeup of aglime? How is the value of a particular source of aglime characterized and measured so that the correct amount for a farmer's field may be calculated? Hint: Consider the percent of calcium carbonate in the limestone.
D. Research the physiological reasons for the observed effects of pH on plant growth.
E. What environmental factors could alter the outcome of the planned pH of a farmer's field? How would you change this experiment to develop a model to describe one of these conditions and the effects it might have on crop growth?
F. What other uses are made of this mined material upon which you depend?
G. The United States Geological Survey collects data which indicate that quarrying and mining companies in the United States produce and sell 8.1 tons of crushed stone, sand and gravel (aggregates) for each one of us who lives in the United States every year. How do you depend upon 8.1 tons (~16,200 pounds) of these natural resource products each year?

Learn more at www.MineralsEducationCoalition.org