Soil Acidity and Leaching

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Objective of the Lesson: Soil pH is an important variable in determining soil quality. It influences the retention of nutrient cations (e.g. Ca and K are lost from acid soils by leaching) in soils, the release of toxic metals (phytotoxic Al is mobilized in acid soils as well) and general microbial activity.

This exercise is designed to introduce students to:

- The concept of acids and bases and arouse curiosity about acids and bases in daily life
- Measurement of soil pH
- Effect of soil pH on nutrient cycling and loss
- Environmental impact of soil acidity
- How soil pH may be improved

Standards Addressed:

Science

K-3	4-5	6-8
Standard 1 *Nature and Application of Science and Technology* A-1, A-2, A-3	**Standard 1** *Nature and Application of Science and Technology* A-1, A-2, A-3	**Standard 1** *Nature and Application of Science and Technology* A-1, A-3
_____	**Standard 2** *Earth's Dynamic Systems* C-1	**Standard 2** *Earth's Dynamic Systems* B-1, B-2
_____	**Standard 5** *Earth's Dynamic Systems* A-2	**Standard 5** *Earth's Dynamic Systems* C-1

Agriscience

6-8
Exploring Agriscience Careers **Standard 4** *Plant Science Careers* B-9, B-12
Exploring Agriscience Careers **Standard 7** *Natural Resource and Environmental Careers* B-6

Materials Needed:

- ✧ At least two Erlenmeyer flasks per group
- ✧ Water in squirt bottles;
- ✧ pH indicator paper strips (pH 1 to 14);
- ✧ Vinegar
- ✧ Lemon juice
- ✧ Baking soda
- ✧ Soap
- ✧ Cola
- ✧ Soil samples

Teaching Tips:

- ✧ Students will work in groups of 2 students.
- ✧ This activity is quite messy, allow ample time for clean-up by the students
- ✧ Control the use of vinegar and soda. Students tend to repeat the carbon dioxide evolution experiment.
- ✧ Watch your time during this activity. This activity could be performed over two days, with day one consisting of an introduction to pH in general and day two focusing on pH and soils.
- ✧ This lesson can be altered depending on grade level. If working with older students, they could mix solutions of household acids and bases. However, if working with younger students, solutions should be made in advance with labels of the concentration (i.e. 50% water, 50% lemon juice, etc.). Again, detail can be altered.

Procedure:

Introduction to pH

- ✧ In this section, students should become familiar with pH as a measurement of the acidity or alkalinity of a solution. The extent to which the details are discussed should depend upon the grade level of the students. Examples of acids in household and the sour taste of acids in fruit juices should be mentioned. Exaggerated concepts might exist, such as acids as agents that immediately and completely dissolve objects. It must be stressed that acids exist in different "strengths" according to type and concentration. This can be used to lead into the question how to measure the strength of an acid.

1. If working with older students, demonstrate how to make solutions, including dissolution. Each group should measure pure solutions of tap water, lemon juice, vinegar, and cola. Soap and baking soda will have to be dissolved. Choose a concentration you would like all students to measure. These solutions can be considered the standard solutions.
2. After recording the pH values of the standards, each group may create 10 different solutions containing the different standards. Each group should record all of their data onto the attached sheet.
3. Finally, each group should mix vinegar and soda solution to observe the evolution of carbon dioxide and measure the pH of the neutralized solution. Again, record this data on the sheet.

pH and soils

- ✧ Definition of soil pH is difficult due to the heterogeneous nature of soils and buffering effects of different soil components. An operational definition of the pH of a soil sample is the average pH that is measured in a suspension of the soil sample in water or an electrolyte solution at a defined solid to solution ratio. For our purposes, soil samples from different locations (sandy soil from the water's edge, forest soil etc.) and samples of a commercial "potting soil" are suspended in tap water.
- ✧ Soil pH determines the mobility and leachability of cations and over all influences sorption reactions. Generally, a more neutral soil is preferable over an acid soil, and acid soils are limed to improve their quality.

1. Students prepare suspensions of soil samples in tap water and determine the pH value by either dipping the indicator strip into the suspension, or by dripping a drop of the clear supernatant on it.
2. After determining soil pH, groups should add baking soda in small quantities until neutrality is reached. Groups should record the amount of baking soda that was added to reach neutrality and compare with other groups.

Check for understanding:

Possible Questions

1. What are the pH values of the acids? What are those of the bases? What are those of soap or Cola?
2. What happens if an acid and a base are mixed?
3. What is the pH of the soils?
4. Explain which soil pH is better for farming.
5. Why would a soil require lime or baking soda to be added? How much soda has to be added to reach a pH value better suited for farming?
6. How does the addition of lime change a soil?
7. How can soils become too acidic?

Suggested Answers

1. Acids have a pH value less than 7 and bases have a pH value greater than 7. Neutral solutions have a pH of 7.
2. If an acid and base are mixed, the solution pH is pushed towards neutral or 7. How quickly and precisely this takes place is dependent upon the amounts and concentrations of the acids and bases that are combined.
3. The pH should be slightly basic (above 7).
4. Nutrients that are necessary for healthy plants need to be dissolved before uptake by plants. Dissolution of these nutrients usually takes place in neutral to slightly acidic pH values.
5. A soil may require the addition of lime to raise the pH for nutrients to dissolve. An acidic pH may also release cations such as manganese (Mn), aluminum (Al) or iron (Fe), which can be harmful to plants.

The amount of soda added is dependent upon the initial pH of the soil, the texture or grain size of the soil and the amount of organic matter in the soil.

6. The addition of lime raises the pH of the soil and also replenishes necessary nutrients such as calcium (Ca) and magnesium (Mg). Lime may also release previously unavailable phosphorus and makes nitrogen more available by slowing down the decomposition of organic matter. Lime is added naturally to soils when surrounding limestone (calcium carbonate – $CaCO_3$) or dolomite (magnesium rich carbonate – $MgCO_3$) is dissolved.
7. Soils may become acidic through the addition of organic or inorganic acids produced by decaying organic matter or the oxidation of ammonium or fertilizers.

Summary of learned material:

One factor to consider in examining soil materials is pH. The pH value of a solution measures the acidity or alkalinity of that solution. In soils, neutral (pH= 7) to slightly basic (pH=8 – 9) is favorable. Acidic soils release cations that may harm plants and do not allow nutrients vital for plants to dissolve. The pH of a soil may be made more alkaline by adding lime, either naturally through the dissolution of carbonate minerals, or by anthropogenic means.

Additional Resources:

General sites – Soil Acidity:

http://www.gov.on.ca/OMAFRA/english/crops/facts/91-086.htm#c2

http://hubcap.clemson.edu/~blpprt/acidity2_review.html - good charts and images

http://hubcap.clemson.edu/~blpprt/pdf/acidity1.pdf - pdf file of above website

General Sites – Soil Leaching

http://davesgarden.com/terms/go/530/ - definitions

Adjusting the pH of your garden:

http://www.thegardenhelper.com/acidsoil.html