

## Chemistry and Environmental Sciences

### *There's A Hole In My Umbrella*

(a mini-unit on acid deposition)

#### **Objective:**

Students will gain an understanding of acid deposition and the environmental impact it has both nationally and globally.

#### **National Science Standards:**

As a result of these activities, students in grades 9-12, will

- develop skills in scientific inquiry (standard A).
- observe changes in properties of matter (standard B).
- gain an understanding of environmental quality related to both natural and human-induced hazards (standard F).
- understand that science is a global challenge (standard F).
- evaluate results of scientific experiments and observations (standard F).

#### **Benchmarks for Scientific Literacy:**

By the end of the 12<sup>th</sup> grade, students should know

- investigations are conducted for different reasons including to test how well a theory predicts.
- Humans are part of Earth's ecosystems and human activity can, deliberately or inadvertently, alter the equilibrium of ecosystems.

#### **Teacher Notes:**

Websites for the basics of acid deposition (acid rain)–

<http://www.epa.gov/rgytgrnj/programs/artd/air/acidrain/acidrn2.htm>

<http://www.ec.gc.ca/acidrain>

Website for pH scale –

<http://staff.jccc.net/PDECELL/chemistry/phscale.html>

Website for Hysplit –

<http://www.arl.noaa.gov/ready/hysplit4.html>

Website for global acid deposition locations –

<http://www.angelfire.com/ks3/acidrainreport/global.html>

Videos:

Acid Rainbows

Acid Rain: Invisible Threat

To Catch A Cloud: Thoughtful Look at Acid Rain

Could email other schools nationwide and request soil samples to use.

Collect milk jugs ahead of time. Need 3 per 2 lab groups.

Plant the 3 cups for the vegetation study 2 weeks before starting this unit; could use purchased plants for the vegetation study; could have different groups do different kinds of plants; use fast plants ([www.fastplants.org](http://www.fastplants.org)).

**Engage:**

1. Have students look at a set of pictures that represent hazards associated with acid deposition. ASK: What do you think is happening? Are there any possible relationships between these photos? Explain idea.
2. Use picture of umbrella to announce topic of unit.
3. Distribute KWL chart. Students should record information in the first 2 columns.

Materials needed for this section:

- 5 pictures
- 1 - KWL chart per student

**Explore:**

Through lecture and discussion, students need the following review and/or background:

- Definition of air quality and air pollution
- List of natural pollutants and man-made pollutants
- Identify 7 criteria pollutants
- Definition and discussion of acid deposition
- Identify most common pollutants responsible for acid rain and sources.
- Discussion of effects

Complete activities 1 and 2.

Materials and procedures are listed on lab sheets.

Locate a news article related to some aspect of acid deposition/rain. Article should be current (1995 to present). Read and summarize to class including location affected and what impact the article could have on you.

**Explain:**

1. Re-evaluate the four photos from engage. Write a short paper explaining the relationship between them by expressing your knowledge of acid deposition/acid rain.
2. Why is acid deposition (acid rain) considered air pollution?
3. Based on US pH isopleth map and your knowledge of industrialization around the globe, what other areas of the world do you think have acid deposition issues? Why? (see activity 3)
4. Compare the current pH map with previous years. We have better emission control standards yet similar acid rain patterns. Why?

**Extend:**

1. Experiment with the buffering capacity of soil types.
2. Experiment with chemical weathering susceptibility of rocks – limestone, marble, granite, etc.
3. Use purchased test kits for SO<sub>2</sub> and NO<sub>2</sub> to analyze local air.
4. Make a wind rose and use Hysplit site.
5. Construct an isopleth map of the US pH values. Use the map at <http://water.usgs.gov/nwc/NWC/pH/html/ph.html>

**Evaluate:**

Completed KWL  
Collect activity sheets and graph  
Monitor participation  
Article summary/share

Name \_\_\_\_\_

## Activity 1

### Acid Deposition and Plant Growth/Vegetation

#### Materials:

3 milk jugs/2 groups	Marker
3 spray bottles/2 groups	Teaspoon and/or eye dropper
Vinegar	Metric ruler
pH paper or pH meter	Graph paper
Distilled water	Colored pencils
6 Styrofoam cups or 250 ml beakers	pH scale
Potting soil	
6 seeds – radish, marigold, soybeans or your choice	

#### Initial prep:

1. Fill 3 milk jugs with distilled water. Label one neutral, one average rain and one acid rain. Add small quantities of vinegar to the average rain and acid rain jugs until pH is adjusted as close as possible to 5.6 and 4.0 respectively. Use pH paper or a pH meter to test pH. Be sure to shake contents up after adding vinegar before testing pH. Two groups will share milk jugs and prepared water.
2. Label 6 Styrofoam cups as follows. “G” represents the growth lab and “V” represents the vegetation lab.

G – neutral

V - neutral

G – average rain

V – average rain

G – acid rain

V – acid rain

Put your names and class period on the cups also.

3. Fill each cup with potting soil within ½” of the top.
4. Plant 1 seed in each cup according to package directions. Be careful to plant each seed at an equal depth.
5. Water each cup according to need using the proper rainfall type. The 3 cups marked “V” will all be watered with the average rain container until plants emerge.
6. Place cups in the greenhouse.

#### Part A: Plant Growth Study – use cups labeled “G” for this section.

1. Each day, measure in mm the growth observed.  
Record in data table. This will be an ongoing process for 20-25 days.
2. When data is completely obtained, graph results. Construct a multi-line graph, putting days on the horizontal axis and height on the vertical axis. Be thorough with your graphing!
3. Clean-up. You may take your plants home and plant them if you wish (especially the neutral and average rainfall plants).

#### Part B: Vegetation Study – use the cups labeled “V” for this section.

1. After your plants have emerged and have established themselves, you will water from above using a spray bottle that contains your rainfall mixtures. Spray bottles will be shared with another group.
  2. Record your initial observation of the vegetation on all 3 plants on the data table. Notice color, strength of stems, leaf development, etc.
  3. Daily, remove your plants from the greenhouse and introduce appropriate rainfall to all containers for 2 weeks.
  4. At the end of 2 weeks, make another observation and describe your findings in the data table.
- You could record both of your observations digitally with a series of photos.

## Data Table – Part A

Type of Seed Planted - \_\_\_\_\_

PART A: Growth will be measured (in mm) as the distance above the surface of the soil.

	Neutral rainfall pH = _____	Average rainfall pH = _____	Acidic rainfall pH = _____
Day 1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			

Activity #1

## Data Table – Part B

### Vegetation Observations

	Initial observation of vegetation	Observation after exposure to different rainfall pH
V-Neutral		
V-Average Rainfall		
V-Acid Rain		

Name \_\_\_\_\_

## Activity #2

### Corrosion of the Statue of Liberty

In the early 1980's, the Statue of Liberty in New York Harbor, had to be refurbished due in part to the effects of acid deposition. In this activity, you will determine why this had to be done.

#### Materials:

Plastic container with lid  
Penny (or 2)  
Vinegar  
Paper towel  
Water  
Salt

#### Procedures:

1. Record the year your penny was minted and its' initial weight in grams.
2. Saturate a paper towel and wring out excess water. Fold and place towel in the bottom of your container.
3. Add 1 tsp. vinegar and a dash of salt.
4. Put you penny on the paper towel, cover the container and leave in an undisturbed place overnight.
5. After 24 hours, observe, recover and leave undisturbed for another 24 hours.
6. Cleanup.

Data: Record the necessary information below. Be sure to make a visual observation of the penny before starting then note any changes after 24 hours and 48 hours.

Year of Penny - \_\_\_\_\_

Initial Weight - \_\_\_\_\_ g

After 48 hours of chemical change - \_\_\_\_\_ g

Describe what your penny looked like after 24 hours.

Describe what your penny looked like after 48 hours.

What do you think happened?

Research the relationship between a penny, the Statue of Liberty and the chemical change that occurred. Write a brief paragraph explaining your thoughts.

## Current events related to acid deposition:

### Is Acid Rain Killing Off Wood Thrushes?

Robert Winkler  
for National Geographic News  
August 13, 2002

Acid rain may be forgotten, but it is not gone, and now researchers at the Cornell Laboratory of Ornithology have linked it to the decline of the wood thrush, a forest bird known for its beautiful song.

### Iowa's oaks fade from landscape

Deer, disease, other species hurt symbol

[By PERRY BEEMAN](#)

REGISTER STAFF WRITER

**June 14, 2006**

Iowa's state tree, the oak, is hurting.

Part of the problem is a group of diseases and conditions with names like oak wilt and oak tatters that cause damage residents should watch for, experts say.

Much of the situation is just nature. Without the benefit of fires that kept species in balance before widespread farming and development, Iowa's landscape is heavy on shady maples and basswoods and increasingly light on hardy, acorn-producing oaks.

## Activity #3

**Prevailing (Average) Direction vs. Acid Rain Impact Zones**

Is there a connection between average wind direction and areas experiencing high concentration of acid rain?

**Materials:**

Compass  
Ruler  
Paper  
Pencil  
Map of U.S.  
Computer  
Local weather

**Engage:**

Students will make a local wind rose for a 2 week period of time.

## Making a wind rose:

- Use a compass to draw concentric circles ½” apart. Use a ruler to divide this circle into an 8 point compass.
- Take a wind direction reading, daily at the same time, for 2 weeks.
- For each day, darken a rectangle representing the measured direction (if calm, darken the center of the circle).

What is the most common wind direction occurring over this time period?

**Explore:**

Locate the prevailing wind direction for the following cities that are scattered between the acidic NE United States and the rest of the country.

City	Prevailing Wind Direction
Omaha, NE	
Chicago, IL	
Pittsburgh, PA	
Albany, NY	
Denver, CO	
Reno, NV	
Portland, OR	
Boston, MA	
Columbus, OH	

Washington, DC	
Bangor, ME	
Bismarck, ND	
Nashville, TN	
Detroit, MI	
Charlotte, NC	
Phoenix., AR	
Los Angeles, CA	
Lexington, KY	
Cleveland, OH	
Oklahoma City, OK	

On a map U.S. map, locate these cities and draw an arrow representing the average wind direction. Make the arrow approximately 3/4" long.

**Explain:**

Compare your constructed map with a pH isopleths map at [www.nadp.sws.uiuc.edu/isopleths/map2004/phlab.pdf](http://www.nadp.sws.uiuc.edu/isopleths/map2004/phlab.pdf).

Do your arrows show that pollutants would move downwind from these cities and contribute to the acid rain concern in the NE United States?

**Extend:**

Go to Hysplit ([www.arl.noaa.gov/ready/hysplit4.html](http://www.arl.noaa.gov/ready/hysplit4.html)) and click on the following links:

- Click Meteorology
- Click Archived global
- Enter the latitude and longitude coordinates for 5 of the above cities.
- Type in the password
- Choose wind rose

Is that city experiencing a normal wind direction day?

Does the wind rose you produced early look like these?

Is there a connection between prevailing wind direction and the NE United States? Support your answer.

From the maps, Iowa doesn't appear to have a problem with acid rain. We live in an area of clean air and good soil. Does that mean pollution isn't a problem here? Complete activity 4

**Evaluate:**

- Completed local wind rose
- Completed map showing prevailing wind directions.
- Participation and exploration of Hysplit website.

## Activity #4

**Pollutants and Your Health**

Does pollution present a health issue in Iowa?

**Engage:**

Pick 5 states you would like to visit or maybe even live in. Pick 5 cities in Iowa (find a zip code for that city) that you have visited, lived in or have relatives that live there. List these below. You must include the town you live in.

U.S. City	Towns in Iowa	Zip Code for Iowa Town

**Explore:**

Go to <http://www.scorecard.org>

Click on smog and particulates. Read and explore the site. Go to pollution locator and enter the state you are interested in. Go to “provide your zip code” and study the information about the towns you listed.

Repeat by clicking on hazardous air pollutants and repeat the above.

**Explain:**

What pollutants are most prevalent in Iowa?

How does Cass County rank within the state?

Besides cancer, what other health risks are associated with pollutants?

**Evaluate:**

Evaluate student participation and their conclusions to above questions.

How is Iowa indirectly affected by the acid rain problem in the NE United States?