Air Quality Module
Kaizen: Continual Improvement

I. Introduction: Acid Rain Drops

Background: No matter where you live, the air you breathe contains air pollutants. The Clean Air Act, passed by the US congress in 1977, was intended to govern the release of certain pollutants into the air. In 1990 the Clean Air Act was amended and now requires EPA to set acceptable limits for six of the major air pollutants: carbon monoxide, lead, nitrogen dioxide, particulate matter, ozone, and sulfur dioxides. These standards are referred to as the National Ambient Air Quality Standards.

Sulfur and nitrogen oxides mix with the water vapor in the atmosphere producing acid rain. Normal rain has a pH of 5.6 to 6.0. Acid rain is defined as any rain possessing a pH between 2.0 and 5.6. Acid rain has a detrimental effect on plants, animals, soil, water, and entire ecosystems. Acid rain is also responsible for releasing toxic metals that are found in the ground. These metals are then washed into the water supply further polluting ground and surface waters.

The following websites give additional information on the categories, sources, and methods of air pollution:

- http://airnow.gov/index.cfm?action+statiac.aqi
- http://www.k12science.org/curriculum/airproj/airqualitymap.htm
- http://www.airnow.gov
- http://lungaction.org/reports/SOTA06_stateozone.html?geo_area_id=21

Subject Area: Science

Kentucky Connections:

- Learner Goals: #1, #2, #4, #5, #6

- Academic Expectations: 1.1, 1.2, 1.3, 1.16, 2.1, 2.3, 4.2, 5.1, 5.3, 5.5, 6.1, 6.2, 6.3

- Core Content 4.1: SC-06-1.1.2, SC-06-2.3.2, SC-06-2.3.3, SC-06-4.7.1, SC-07-1.1.1, SC-07-1.1.2, SC-07-4.7.1, SS-06-3.4.2, SS-06-4.4.4, WR-M-1.1.0, WR-06-1.1.3, WR-07-1.1.3, WR-08-

1.1.3, WR-M-1.2.0, WR-06-1.2.3, WR-07-1.2.3, WR-08-1.2.3, WR-M-2.3.0, WR-06-2.3.3, WR-07-2.3.3, WR-08-2.3.3, WR-M-2.4.0, WR-06-2.4.3, WR-07-2.4.3, WR-08-2.4.3, WR-M-3.5.0, WR-06-3.5.3, WR-07-3-5-3, WR-08-3.5.3, WR-M-3.6.0, WR-06-3.6.3, WR-07-3.6.3, WR-08-3.6.3

Materials:

- Antacid tablets containing calcium carbonate
- Vinegar (acetic acid)
- Graduated cylinder
- Spray bottle
- 4 100ml beakers (small cups may be used)
- Soil
- Several healthy leaves
- Hydrion paper (pH paper)
- Scales
- Tablespoon

Length of Lesson: One 60 minute class period.

Vocabulary Words:

- EPA: Environmental Protection Agency
- Clean Air Act: Environmental law passed in 1977. This act required coal-burning power plants to install scrubbers to remove sulfur dioxide from their emissions. The act was amended in 1990 to address the problem of acid rain.
- Coagulation: The process of forming semisolid lumps in a liquid.
- Acid rain: Rain possessing a pH between 2.0 and 5.6.
- Pollutant: Any substance, such as certain chemicals or waste products, that renders the air, soil, water, or other natural resource harmful or unsuitable for a specific purpose.
- Acid: Substance with a pH below 6.9.
- Alkali: Substance with a pH above 7.1.
- Neutral: Substance with a pH of 7.
- PH: A numerical scale, 1-14, that measures hydrogen ion concentration.
- Distilled water: Water from which impurities, such as dissolved salts and colloidal particles, have been removed by one or more processes of distillation; chemically pure water.

Essential Question: How does acid rain affect plants?

Guiding Questions/Outcomes:

- Students will be able to define acid rain.
- Students will be able to describe the causes of acid rain.
- Students will be able to explain the effects of acid rain on soil and plants.

Skills Used:

- Observing
- Comparing
- Organizing

Activity:

- **Part I**
  - Take a 5 gram (tablespoon) sample of soil and place in a 100 ml beaker.
  - Add 10 ml of distilled water to the soil.
  - Stir well and let stand for 20 minutes.
  - Use the Hydrion paper or pH paper to check the pH of the soil solution.
  - A pH test kit may be used if available through the science department**.**

- **Part II**
  - In a second 100 ml beaker place an antacid tablet containing calcium carbonate. Calcium carbonate is a major component of limestone rock.
  - Add 15 ml of vinegar to the antacid tablet.
  - Observe for 10 minutes.
  - This simulates the action of acid rain on soil.

- **Part III**
  - Get two 100 ml beakers and label them Beaker #1 and Beaker #2.
  - Fill each beaker full of soil from the same source as the sample used in Part I.
  - Obtain 2 green healthy leaves and insert one into each beaker.
  - Spray Beaker #1 with distilled water. Continue spraying until the water has covered the leaf and begins to run into the soil.
  - Spray Beaker #2 with 100% vinegar. Continue spraying until the vinegar has covered the leaf and begins to run into the soil.
  - Spray each beaker at least twice during the class period.

- Let the beakers stand overnight.
- Day 2: Observe the leaves in each beaker and record observations.
- Use the procedure in Part I to measure the pH of the soil.

Assessment:

- Have students make a collage of pictures showing the effects of acid rain.
- Have the students research the major air pollutants in your area and report to the class on their source and effects.

Extensions:

- Have students research the Clean Air Act.
- Have students do a comparison of the National Ambient Air Quality Standards and the Air Quality Index for their neighborhood**.**

TMMK Connection

1. Toyota uses boilers fueled by natural gas to heat the plant. Although natural gas contributes to the production of acid rain, TMMK uses low NOx (nitrogen oxide) boilers to minimize the amount of nitrogen oxide emitted into the air. Fuel oil (which produces sulfur dioxide when burned) is used only in circumstances where natural gas supplies are curtailed.
2. TMMK has implemented a strong energy conservation program throughout the plant. Although this does not impact emissions at the TMMK plant, it does reduce emissions from the local power plant since less energy is needed. This also helps to preserve our natural resources.
3. In TMMK's Powertrain shop large exhaust fans are equipped with filters designed to trap "fugitive" particulates.
4. Toyota's paint booths' down draft air carries airborne paint particles into a stream of flowing water, which keeps most of the particles from entering the atmosphere. The paint laden water flows into a sludge pool where the paint particles are removed by a coagulation process.
5. Paints and solvents containing volatile organic compounds (VOCs) are the major air pollutants in the two paint shop areas and the plastic shop. Thermal oxidizers are used in Paint Shop I to remove VOCs before the air is released from the plant. Paint Shop II uses a combination of carbon absorbers and thermal oxidizers to remove excess paint solvents from the air. The Plastic shop uses similar devices to control VOC emissions.
6. As another means to reduce VOC (solvent and paint) emissions, TMMK uses water based paints for some of the coatings in the paint and plastic shops. Waterbased paints typically have 5-10% VOC content where solvent based paints have 30-40% VOC content.
7. In the Body Weld section of Toyota's plant, the major air pollutant is particulate matter coming from the welding processes. Dust hogs, containing special filters, and wet scrubbers are used to remove a large portion of the particulates from the air before it is released to the atmosphere.
8. All areas at TMMK follow the "controlled usage of solvents" rule. This means work practices are in effect to minimize the amount of solvent being used.
9. TMMK checks 20 different sites outside the plant for odors that would indicate pollutants being released into the atmosphere. Odors are rated on a scale of 0-5. Any odor registering 3 or above is investigated.

Student Data Sheet

Name _____

Date_____

Part I:

1. What was the pH of the original soil sample? _____

Part II:

2. What happened to the antacid tablet? _____

3. What evidence did you see that indicated a chemical change was taking place between the antacid and the vinegar? _____ _____.

Part III:

Use your observation of the plant leaves to complete the following table.

	Beaker 1	Beaker 2
Describe the appearance of the leaf at the start of the activity.		
Describe the appearance of the leaf at the end of the activity.		

1. What was the purpose of spraying distilled water on the leaf in beaker #1? _____

2. What was the pH of the soil in beaker #2 at the end of day 2?_____

Conclusions:

1. What effect does acid rain have on the pH of soil? _____

2. What effect does acid rain have on plant life? _____

II. TMMK fieldtrip observations

1. TMMK has large air ducts throughout the plant. What is the purpose of the vents located above the team members? _____
   _____
   _____

2. What does a "wet scrubber" use to remove particulates from the air? _____

3. Describe any odors you detected in the following sections of the plant.

   Assembly: _____
   _____
   _____

   Body Weld: _____
   _____
   _____

   Stamping: _____
   _____
   _____

   Plastics: _____
   _____
   _____

4. What is the difference between "live paint" and "dead paint"?
   _____
   _____
   _____
   _____

III. Conclusion: Acid Rain Drops

Background: In the industrial age we live in, it is unrealistic to expect to eliminate all air pollutants in the air. Essentially this means that no matter where you live the air contains some gases and pollutants that are potentially hazardous to your health and to the health of other plants and animals. This unit is focused on sulfur and nitrogen oxides as they relate to the production of acid rain. The occurrence of acid rain depends on the area where you live and the concern local industry has for air quality.

Subject Area: Practical Living**,** Science, Social Studies, Writing

Kentucky Connections:

- Learner Goals: #1, #2, #5, #6

- Academic Expectations: 1.1, 1.2, 1.3, 1.11, 1.12, 1.16, 2.1, 2.2, 2.5, 2.19, 5.1, 5.3, 5.5, 6.1, 6.3

- Core Content 4.1: RD-06-2.0.4, RD-06-2.0.5, RD-06-2.0.7, RD-07-2.0.4, RD-07-2.0.5, RD-07-2.0.7, RD-08-2.0.4, RD-08-2.0.5, RD-08-2.0.7, SC-06-4.7.1, SC-07-1.1.1, SC-07-2.3.1, SC-07-4.7.1, SS-06-3.4.3, SS-06-4.1.1, SS-06-4.1.2, SS-06-4.2.2, SS-06-4.4.2, WR-M-1.1.0, WR-06-1.1.3, WR-07-1.1.3, WR-08-1.1.3, WR-M-1.2.0, WR-06-1.2.3, WR-07-1.2.3, WR-08-1.2.3, WR-M-2.3.0, WR-06-2.3.3, WR-07-2.3.3, WR-08-2.3.3, WR-M-2.4.0, WR-06-2.4.3, WR-07-2.4.3, WR-08-2.4.3, WR-M-3.5.0, WR-06-3.5.3, WR-07-3-5-3, WR-08-3.5.3, WR-M-3.6.0, WR-06-3.6.3, WR-07-3.6.3, WR-08-3.6.3

Materials:

- Hydrion paper (pH paper may be used but will not give exact pH.)
- Zip top sandwich bag
- Container with a screw cap lid
- Local topography or road maps
- List of local industries
- Phone book (or use the yellow pages on your computer search engine for addresses and phone numbers)

Length of Lesson: This activity will require students to collect rain samples at home. The in-class activity will require two regular class periods.

Vocabulary Words:

- Acid rain: Broad term referring to a mixture of wet and dry deposition (deposited material) from the atmosphere containing higher than normal amounts of nitric and sulfuric acids.
- Industrial pollutants: Particulates and gas emissions that lower the quality of air, soil or water.
- Topography: The detailed mapping or charting of the features of a relatively small area, district, or locality.

Essential Question: Does industry in your community produce air pollutants that contribute to the production of acid rain?

Guiding Questions/Outcomes:
- Students will be able to identify sources of acid rain.
- Students will be able to describe the locations in their community where the pH of rain is the lowest.
- Students will be able to describe the effects of local industry on acid rain production.

Skills Used:
- Research
- Observation
- Comparing
- Organizing
- Map reading

Activity:

Collection of rain sample:

1. The container used for collecting the sample must be clean. One suggestion is to use a new zip top sandwich bag, opened and used to line a container with a screw cap. If the sandwich bag is new it should be free of contaminates that would effect the pH of the rain.
2. After the rain starts, place the container in an open place in your yard or driveway. Be sure there are no trees, buildings, or electric wires near the container. These could be sources of contamination.
3. Close the zip top bag. Leave it inside the container and cover the container with the screw cap.
4. The sample is now ready to transport to school.

pH test:

1. Open the container and the zip top bag.
2. Use the Hydrion, or pH, paper to determine the pH of the sample.

3. Record the date, time, pH, and location on a chart along with the data from all the other students in the class.

Community mapping:

1. Distribute topography maps or roadmaps of the local community.
2. Each student should locate their collection site and mark the pH of their sample.
3. Each student should mark the location of all industries located near their home.
4. Is the pH more acidic or basic at higher elevations?
5. Is there a relationship between the distance of the sampling site from the nearest industry and pH?

Assessment:

1. Assign each student one local industry and have the student conduct research on the type of products made and pollutants released.
2. Have students prepare an oral or written report on the effects of their industry on the production of acid rain.
3. Have students use the following websites to compare the acid rain condition of their community with other communities.
   www.epa.gov/airmarkets/acidrain/where/index.html
   www.epa.gov/airmarkets/emissions/prelimarp/index.html
   www.epa.gov/airmarkets/acidrain/education/learning.html
   www.enviroliteracy.org/article.php?id=362

Extensions:

1. Invite a local meteorologist to speak to you class about weather and wind patterns.
2. Have students identify locations in the community that have been affected by acid rain. Take a fieldtrip to observe these locations.

Biofilter Trial Project uses lava rock and pine-bark mulch to break down volatile organic compounds. Naturally occurring microorganisms flourish in pine-bark and consume the VOCs. This <u>may</u> replace incinerators to reduce "Greenhouse gas" emissions.