# The

# Copper Basin

# Problem

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## Overview

This is a unit which covers the effects of abiotic factors on the organisms in a specific environment. It is also a means to reinforce the skills and processes involved in the scientific method and to provide the opportunity for students to design their own experiments and to solve a problem.

To introduce the topic and unit, a video of a copper mine in Tennessee is used. The video tells of the history of the mining operations in the Copper Basin and gives facts about the mine and the environment in the area. The video is used to stimulate students to think about the impact that humans have had on the environment. Leading questions are used to focus the students on the issues raised by open pit mining. Students use the answers to these questions as a starting point to develop a set of activities and laboratory experiments to investigate the topics raised by the video. During this time, students also use process skills—hypothesizing, conceptualizing, and analyzing. The class develops their own unit of study with guidance from the teacher. Because of their personal involvement the students are highly invested in their own learning.

The unit covers the following concepts and topics:

- abiotic factors: temperature, humidity, pH
- soil composition
- the water cycle
- nutrient cycles: nitrogen, carbon
- interaction of abiotic and biotic factors
- human impact on an environment
- steps of the scientific method including: hypothesis, data collection and organization, analysis, drawing conclusions
- dependent and independent variables
- use of constants
- designing experiments
- application of knowledge

**Suggested Materials**

| |
|---|
| Copper Basin Video |
| Cardboard |
| Chart paper & markers |
| Eye-droppers |
| Goggles |
| Graph paper |
| Humus or compost |
| Local Soil |
| Maps: local and linked area |
| Metersticks |
| Nitrogen fertilizer |
| Paper towels |
| Petri dishes |
| Plant trays |
| Rulers |
| Scissors |
| Screw-top jars |
| Seeds (corn, pine) |
| Seeds (grass) |
| Simulated Copper Basin Soil |
| Small Cups |
| Soil Tests: pH, P, N, K, S, Cu |
| Sterile Potting Soil |
| Table of Relative Humidity |
| Teaspoon measures (1/8) |
| Thermometers |
| Watch/clock/timer |
| Water Solutions, pH 2–7 |

# Overview of 5E Components

| Description of each section of the 5E model | Teacher Lessons | Short description of lessons and activities | Core Learning Goal Indicators for each activity |
|---|---|---|---|
| **I Engagement:** This activity captures the students' attention, stimulates their thinking, and helps them to access prior knowledge. | Lesson 1 | A 10-minute video of a copper mine in Tennessee is shown to introduce a situation in which human impact has had several negative effects on an environment. The video also presents issues for investigation that show the interrelationship between abiotic and biotic factors. | 3.5.1, 3.5.3, 3.6.1 |
| **II Exploration:** In this section students are given time to think, plan, investigate, collect and organize information. | Lesson 2 | Students design a set of experiments that will address some of the problems and issues raised by the video. They will employ all of the steps of the scientific method. Students developed the following investigations: | 1.2.1, 1.2.3, 1.2.4 |
| | Lesson 3 | **Will Plants Grow in Copper Basin Soil?** (Student Investigation 1) | 1.2.2, 1.2.5, 1.3.2, 1.4.1, 1.5.1, 3.5.1, 3.5.3 |
| | | **What Chemicals are Found in Copper Basin Soil?** (Student Investigation 2) | 1.2.2, 1.2.3, 1.2.5, 1.3.1, 1.3.3, 1.4.1, 1.4.2, 1.4.5, 1.5.1, 1.5.2, 3.5.1, 3.5.3 |
| | Lesson 4 | **How Does the Amount of Vegetation Affect Humidity and Temperature?** (Student Investigation 3) | 1.1, 1.2, 1.3, 1.4, 1.5, 3.5.1, 3.5.3 |
| | Lesson 5 | **How Does Acid Rain Affect the Germination of Seeds?** (Student Investigation 4) | 1.1, 1.2, 1.3, 1.4, 1.5, 3.5.3 |
| | | *Optional Investigation:* **Air sampling for $SO_2$** | |
| | Lesson 6 | **What Effect Does Fertilizer Have on the Growth of Plants?** (Student Investigation 5) | 1.1, 1.2, 1.3, 1.4, 1.5, 3.5.3, 3.5.4 |

| Description of each section of the 5E model | Teacher Lessons | Short description of lessons and activities | Core Learning Goal Indicators for each activity |
|---|---|---|---|
| **III: Explanation**: Students are now involved in an analysis of their own explorations. Their understanding is clarified and modified because of the reflective nature of the activities. | Lesson 7 | Students will collect and share all of the data that has been gathered. Through discussion, students will assemble the data and begin to form conclusions. Students may present their findings in an appropriate manner. | 3.6 |
| **IV Extension:** This section gives students an opportunity to expand and solidify their understanding of the concepts and to apply them in a real-world context. | Lesson 7 (continued) | Students gather information about a local mining operation and assess the effects of mining on the environment. The students will relate what they learned from the Copper Basin problem to this local situation. (Charles County has gravel pits that cause problems similar to those in the Copper Basin.) Students will link electronically with a school in another area to share data about other mining operations. (We shared with a school in Western Pennsylvania about coal mining.) | Goal 1, 3.5.3, 3.5.4, 3.6 |
| **V Evaluation:** This performance-based activity helps students to connect all of the pieces of information involved in these lessons. | Lesson 8 | Students are assigned the task of presenting the results of a comparative study of the situations investigated. Students developed the rubric and decided upon the project requirements. | Goal 1, 3.6 |

# Student Section

***This section contains samples of investigations developed by students to address the issues presented in the Copper Basin video.***

**I encourage you to work with your students to design their own investigations.**

# Will Plants Grow in Copper Basin Soil?

## Student Investigation 1

(Coordinates with Teacher Lesson 3)

In this activity we will study the effect of Copper Basin soil on the growth of plants. We will compare the growth of plants in simulated Copper basin soil to plants grown in other types of soil. We will also use compost or humus and local soil.

**Problem:**
Will plants grow in simulated Copper Basin soil?

**Materials**:

| | |
|---|---|
| 18 pine seeds | metric ruler |
| 18 corn seeds | plant tray |
| 6 small cups | local soil |
| simulated Copper Basin soil | |
| humus or compost | |

**Procedure**:

1. Predict the result when the seeds are planted in each type of soil. Record the predictions.
2. Construct tables in which to record your observations.
3. Fill the cups with soil as follows:
   - 2 cups with compost or humus
   - 2 cups with local soil, and
   - 2 cups with simulated Copper Basin soil.

   Punch small holes in the bottom of the cups for drainage. Label the cups.
4. Plant 4-5 corn seeds in each type of soil and 4-5 pine seeds in each type of soil. Plant seeds about 1 cm deep. Moisten the soil. Keep it moist for the next few days, but do not overwater it.
5. Put the labeled cups on a plant tray and store it in a warm place. Wash your hands when finished.
6. Observe the cups daily for the next several days. Record any observations. Once the plants begin to grow, record this date and measure the height of the plant each day. Record your observations.
7. At the end of the experiment determine the mean height for each seed that grew in each type of soil.
8. Dig up the seeds that did not grow. Record any observations that can be made such as appearance, color, or partial germination. Find the mass of each seed that did not germinate and record.

# Student Worksheet #1
# Will Plants Grow in Copper Basin Soil?

## Predictions

## Data Table

## Observations

## Analysis

1. In which types of soils did the seeds germinate? _____
   a. How many seeds germinated in each type of soil? _____
   b. How did the heights and general appearance of the seedlings compare across soil types? _____
   _____
2. Explain changes observed in the seeds that did germinate? _____
   _____
3. How many seeds did not germinate in each type of soil? _____
4. Explain changes observed in the seeds that did not germinate. _____
   _____
5. Did the results of the experiment support your predictions? Why or why not? _____
   _____
6. What inferences can you make about the problems identified in the Copper Basin video?
   _____
   _____

# What Chemicals are Found in Copper Basin Soil?

## Investigation 2

(Coordinates with Teacher Lesson 3)

The soil used to reclaim the land that was destroyed by copper mining in Ducktown, Tennessee, contained minerals left from the roasting and smelting processes. The depleted soil apparently did not allow for reforestation of the area. In this lab we will analyze soil from the Copper Basin for its chemical content. The procedures focus on the chemicals needed for plant growth and those that might remain in the soil as a result of mining. The chemicals found in fertilizers are nitrogen, phosphorus, and potassium. Mining probably left behind some types of copper compounds and sulfides. We will also test local soil and humus for comparison. Later we can correlate these results with the observations from the previous investigation.

**Problem**

Does the Copper Basin soil contain chemicals that will support the growth of plants?

**Materials**

Chemical test kits for soil analysis soil samples

**Procedure**

1. Read all cautions and safety procedures for each of the chemical tests. Follow the directions carefully when performing each of the chemical tests.
2. Construct a chart in which the results of each test can be easily recorded.
3. Perform the following soil tests;
    - pH
    - Phosphorus
    - Nitrogen
    - Potassium
    - Sulfide
    - Copper
4. Clean up your lab station and wash your hands.
5. Compare your results with those from other groups.

# Student Worksheet #2
# Will Chemicals are Found in Copper Basin Soil?

## Data Table

## Observations

## Analysis

1. What does the data reveal about the Copper Basin soil? _____
   _____
2. What chemicals may have inhibited the growth of plants in Copper Basin soil?
   _____
3. How do the results from the investigation, "Will plants grow in Copper Basin Soil?" support or refute the results of this investigation? _____
   _____
4. Based on this investigation, what are some possible solutions to the revegetation problems in the Copper Basin? _____
   _____
5. How does the evidence found in this investigation relate to the original list of issues and problems? _____
   _____

# How Does the Amount of Vegetation Affect Relative Humidity and Temperature?

## Investigation 3

(Coordinates with Teacher Lesson 4)

Organisms lose water faster in an atmosphere with lower humidity than in an atmosphere with higher humidity. The barren Copper Basin had much less vegetation than the forested area surrounding it. Two abiotic factors, temperature and relative humidity, might be very different in each area. We will measure and compare the temperature and relative humidity in three microenvironments at different heights and compare the results. We can use the results to predict if the barren land in the Copper Basin could have caused changes to the micro-climate in that area.

**Problem**

Does the amount of plant life affect the relative humidity and temperature of an environment?

**Materials**

3 watches/clocks/timers
3 metersticks
3 thermometers (dry)
3 thermometers
(with cotton sleeve over bulb end)
3 screw top jars of 30-50 mL distilled water
3 pieces of stiff cardboard for fanning
3 shade devices
Table of Relative Humidity

**Procedure**

1. Predict differences that will be found in the 3 different environments.
2. Divide the team into 3 pairs of students. Each pair will measure the temperature in one of the three environments at 0 cm, 10 cm, 90 cm, and 150 cm. The 3 environments are:
   - the woods (dense cover of plants)
   - the edge of the field (thicket or shrubby area), and
   - the middle of the soccer field (barren ground).
3. One person in each team should record the data. Teams should synchronize their timers. Write the synchronized times on a chart. All measurements should be made at the same times. Schedule at least 10 minutes between readings.
4. Wet the cotton sleeve of one thermometer with distilled water. This should be done before each reading.
5. Read both thermometers at the same time. Position the thermometers at least 2 minutes before a reading so that the temperature can stabilize. Use the shade device to shield the thermometer from the direct rays of the sun. Fan the thermometers with the stiff cardboard for 2 minutes, then read the 2 temperatures and record your readings. Repeat this procedure at each height.
6. Using your measurements and the relative humidity chart, determine the relative humidity. *Relative humidity* is the percent of water vapor actually in the air at any given temperature compared to the amount of water vapor the air could hold at that temperature.
7. Share results with the other teams.

# Student Worksheet #3
# How Does the Amount of Vegetation Affect Relative Humidity and Temperature?

## Predictions

## Data Table

## Observations

## Analysis

1. At ground level, which environment is coolest and most humid? Which is warmest and least humid? _____
_____
2. How do these two environments compare at the other heights with regard to temperature and humidity? _____
_____
3. What differences in the 3 environments could account for the differences in humidity and temperature? _____
_____
4. How do these differences show the interrelationship between abiotic and biotic factors?
_____
_____
5. How might these results explain the microclimatic changes that were observed in the Copper Basin? _____
_____

# How Does Acid Rain Affect the Germination of Seeds?

## Investigation 4

(Coordinates with Teacher Lesson 5)

Acid rain is a big problem in the Copper Basin area. The local residents reported damage to the leaves of trees after periods of rainfall or fog. In this investigation, we will determine the effects of acidic conditions on plants. Because of the need for a controlled environment in the lab, we will examine the effect of pH on the germination of seeds.

**Problem**

How does pH affect the germination of seeds?

**Materials**

| | |
|---|---|
| petri dishes | ruler |
| wax pencil | water solutions: pH 2, 3, 4, 5, 6, & 7 |
| paper towel disks | (simulated rainwater) |
| scissors | seeds |

**Procedure**

1. Construct a table on which to record your observations.
2. Predict what will happen to seeds grown in solutions of differing pH. Record your predictions.
3. Cut disks of paper towel to fit the bottom of a petri dish. Place 4 paper towel disks in the bottom of each petri dish.
4. Dampen the disks with one of the pH solutions. Label the lid of the petri dish with this pH. Measure the lengths of the 5 seeds that are to be placed in this dish and record these measurements. Place the seeds in the petri dish and cover.
5. Repeat this procedure using the other pH solutions. There will be a total of 6 dishes.
6. Each day, remove the lids of the dishes. Measure the seeds and record your observations on a data table. If necessary, add appropriate solutions to keep the seeds moist.
7. On the last day share your results with other groups.
8. Construct a line graph of the <u>averaged</u> results.

# Student Worksheet #4
# How Does Acid Rain Affect the Germination of Seeds?

## Predictions

## Data Table

## Observations

(Graph your results on a separate sheet of graph paper.)

## Analysis

1. What seems to be the optimum pH for germination? _____
2. Does any pH seem to inhibit the growth of seeds? Explain. _____
   _____
3. What impact might acid rain have on the growth of young plants in a forest or revegetated area? _____
   _____
4. How does the data help to explain issues or problems identified in the Copper Basin video?
   _____
   _____

# What Effect Does Fertilizer Have on the Growth of Plants?

## Investigation 5

(Coordinates with Teacher Lesson 6)

The nitrogen cycle is important for the growth of plants. Our chemical tests of the soil indicated a shortage of nitrogen in the Copper Basin soil. In this experiment we will show that adding fertilizer to the Copper Basin soil could improve its ability to grow plants.

**Problem**

How does fertilizer affect the growth of plants in an ecosystem?

**Materials**

| | |
|---|---|
| small cups | ruler |
| 1/8 teaspoon measures | nitrogen fertilizer |
| grass seeds | potting soil |

**Procedure**

1. Construct a table in which to record your observations.
2. Predict the effect of fertilizer on the growth of grass plants.
3. Fill 9 cups with potting soil. Add the same number of grass seeds to each cup (use at least 10 seeds/cup). Label the cups 1 – 9.
4. To cups 1–8, add amounts of fertilizer in increments of 1/8 teaspoon. Do not add fertilizer to cup 9. Place cups in a sunny location.
5. Observe the cups daily and observe any changes in the color of the grass. Measure and record the average height of the plants in each cup.

# Student Worksheet #5
# How Does Fertilizer Affect the Growth of Plants?

## Predictions

## Data Table

## Observations

## Analysis

1. Describe any changes observed in the cups. Based on the results, what is the effect of fertilizer on the growth of plants? _____
   _____
2. How do these results relate to the problem identified in the Copper Basin video? ___
   _____
   _____
3. What may have depleted the Copper Basin soil of nitrogen? _____
   _____

# Evaluation

**The students and teacher should collaborate to design an appropriate assessment method.**

**My classes developed the following assessment and rubric.**

# Copper Basin Study

Working with your team, choose a way to present all the findings related to the Copper Basin problems and issues. The presentation must include all data that has been collected and its relationship to the Copper Basin problems must be clear. Possible solutions to problems that were suggested and tested in the investigations must also be included.

**Must have list**

Data summary
How collected data relates to overall problem
Conclusions from all tests and investigations
Proposed solutions
Whole group participation

**Project Ideas**

Report
Video
Brochure
Skit
Poster presentation
Informational Booklet
Oral presentation
Computer presentation

# RUBRIC FOR PRESENTATION

| | INFORMATION | EXPLANATION | **INFERENCES AND CONCLUSIONS** WITH SUPPORT | LEVEL OF UNDERSTANDING |
|---|---|---|---|---|
| **4** | Complete | Thorough and concise | Logical progression supported by data | Full |
| **3** | Most | Mostly correct | Acceptable, some support | Good |
| **2** | Some | Basically correct | Acceptable, weak support | Basic |
| **1** | Minimal | Ambiguous | Lacks logical progression, lacks support | Some |

# Teacher Section

Directions

Suggestions

Resources

# Getting Started

# LESSON 1

**Objectives:**

- To introduce a situation in which humans have had a negative impact on the environment;
- To identify issues to be investigated related to the Copper Basin video.

**References:**

Biology; A Community Approach (for videos), Southwestern Educational Publishing, 1992
BSCS –Green, Chapters 1-3

**Materials:**

Copper Basin Video or photos of a strip mining operation
Chart paper and markers

**Procedure:**

1. Introduce the purpose, "We will be studying the impact of human activity on a specific environment. We will be studying the effects of biotic and abiotic factors on the Copper Basin, and applying this information to a local situation."

2. Show students the location of the Copper Basin on a topographic map (Ducktown, TN). [see topozone.com and click on Copper Basin or http://www.topozone.com/map.asp?lat=35.05&lon=-84.3833]

3. Students view the video or the photographs of a mining operation that has stripped the land and depleted the environment. As they observe the video/photographs, instruct them to think about the following questions and to record their answers in their notebooks. After the video, work with the class to discuss the following questions:
   - What issue(s) is/are raised in the video?
   - What problems can you identify?
   - What do you need to know to solve the problems?
   - What experts might we contact to help us?

Following the video, collate all the issues and problems generated by the students. This can be done on the board or on chart paper. (Chart paper allows you to refer back to the list as you progress through the unit). Accept all input.

4. As a class, brainstorm ways to investigate the various problems and issues that were listed.
   - The class usually plans the unit for you. They can be led in a specific direction if necessary.
   - Make a copy for your records and organize the plan into a sequence that is appropriate for you and for your classes.

# Designing an Experiment

## LESSON 2

**Objectives:**

- To design scientific experiments that will help resolve some of the issues from the Copper Basin;
- To employ the scientific method within the design of the students' investigation.

**References:**

Biology texts
Internet access
Reference books

**Materials:**

Notebook
Experimental Design Summaries

**Procedure:**

1. Using the chart paper from Lesson 1, review the list of issues and problems.

2. For each issue, you may want to review the biotic and abiotic factors that apply to the situations, thereby giving the students some background for their experimental design.

3. The class reviews the steps in a well-planned experiment. (I use a laminated handout from a previous lesson for this.)

4. As an introduction to the activity, provide general instructions to the class:
   You will now be designing experiments that you can do to measure some of the factors that were identified previously. You will work in groups to develop valid experimental procedures that are based on the scientific method to explore the issues raised in the Copper Basin video.

5. Divide the class into groups (the number depends upon the number of issues.)

6. To each group, assign a problem or issue that was identified in the video. Give students the remainder of the class period to design their experiments. They should produce a list of materials and a numbered procedure for each experiment.

7. Collect the list of materials and procedures from each group.

## Teacher Preparation for the Next Series of Classes:

1. Review experimental procedures. This will provide an idea of where your students are heading experimentally. Make suggestions that lead them in a specific direction, but do not correct their work.

2. Students should correct and revise their procedures. I have computers in my room and can have students type the revised procedures during class and be ready for the next few days.

3. Develop plan of action:
   PLAN 1 – Each group performs only the experiment they developed and shares the results with the class.
   PLAN 2 – All groups perform every experiment and share results among themselves. I prefer this approach, because as the students perform the experiments, they are learning through a hands-on approach.

4. Contact a local mining operation to arrange a site visit or have a representative come to your class. In Charles County, either option was possible. The classroom visit was more beneficial because the representative brought a video that depicted operations not accessible to students.

5. Classes can also link electronically with students at another school. My classes linked with a school in western Pennsylvania which conducted a similar study of the coal mines that use the stripping technique. The two groups were able to exchange data to make comparisons. Having access to the internet in the classroom made this possible.

# Chemicals in the Soil

# LESSON 3

**Objective:**

- To measure the effects of soil chemistry on the growth of plants.

**Materials:**

simulated Copper Basin soil
potting soil
local soil
compost or humus
seeds
small cups
planting trays
soil tests: pH, Phosphorus, Nitrogen, Potassium, Sulfide, Copper

My classes met this objective in two ways. First, they developed an experiment in which seeds were grown in different soil types and in simulated 'Copper Basin' soil. Next, the students also compared the chemical content of the soils they selected to see if there was some factor in Copper Basin soil that prohibited revegetation.

**Procedure:**

1. The students developed a simple experiment to test soil type on the germination of seeds. *A sample experiment can be found in the student section*. Through research, they discovered the components of the soil in the Copper Basin. I worked with the chemistry teacher to develop the soil. Results of the experiment were recorded daily and analyzed after several days. Following is a recipe for making 'simulated soil' This does not match mine soil exactly, but it does provide the most significant features of the mine soil, especially those that affect plant growth.
   (Copper sulfate is a potent herbicide.)

   - **Mix the following chemicals in 1 liter of distilled water**

| | |
|---|---|
| $CuSO_4$ | 2.0 mg |
| $Fe\ SO_4$ | 138.0 mg |
| $MnSO_4 \bullet 7H_20$ | 30.0 mg |
| $CaHPO_4$ | 7.0 mg |
| $K_2SO_4$ | 41.0 mg |
| $MgSO_4 \bullet 7H_2O$ | 200.0 mg |
| $Ca(OH)_2$ | 278.0 mg |

   - Add 51 mL of concentrated sulfuric acid.
   - Using calcium hydroxide or sulfuric acid, adjust the pH to between 4 and 5.
   - Pour this solution into 1kg of damp sand, mix and allow to dry for several days.

2. They used test kits for soil nutrients and contaminants.

3. The results of both the germination experiments and the soil chemical tests were compared. Some students hypothesized possible solutions to the problem of revegetation and designed investigations to test their own ideas.

4. These soil labs also helped students to analyze the effect of local reclamation projects on previously mined areas. Discussion followed that compared the two situations. Our electronic link with other schools enabled us to compare our own test results to those from students in other geographic regions.

# Relationship Between Vegetation, Temperature, & Humidity

## LESSON 4

**Objectives:**

- To examine the effect of the amount of vegetation on temperature and humidity.
- To relate the experimental evidence to the Copper Basin problem.

**Materials:**

Watches/clock/timer
Meter sticks
Thermometers
Cotton sleeves for thermometers
Screw top jars with distilled water
Stiff cardboard
Shade devices
Table of Relative Humidity

**Procedure:**

1. Through research, students discovered a method to measure relative humidity. *A sample experiment can be found in the student section.* Students worked in teams to measure the temperature and relative humidity in three different micro-environments around the school:
    - Open unshaded area
    - Shrub-covered area
    - Tree-covered shaded area

    Students took measurements at different heights at each of these locations.

2. Roles were divided among team members so that the experiment could be completed within a class period. Remember to establish ground rules for conducting investigations outside.

3. Through discussion and analysis, students related their data to the Copper Basin issue.

4. Electronic links with students in Western Pennsylvania allowed us to share significant data related to other types of mining.

**Extension:**

We obtained permission from a local (Charles County) open-pit gravel mine to collect data on site.

# The Effects of Acid Rain on the Germination of Seeds

## LESSON 5

**Objectives:**

- To test the effects of acid rain on organisms.
- To test air samples for sulfur dioxide.
- To relate the test results to the Copper Basin issues.

**Materials:**

| | |
|---|---|
| Goggles | Ruler |
| Petri dishes | Graph paper |
| Wax pencil | Water solutions, pH 2–7 |
| Paper towels | Rainwater |
| Scissors | Seeds (radishes germinate quickly) |

Optional materials: Air sampling pump, Sulfur Dioxide Test Kit

**Procedure:**

1. One of the issues in the Copper Basin is acid rain that is caused by the formation of sulfur dioxide in the roasting and smelting processes. This has long term effects on the environment and impacts the land for years. Students developed a simple experiment to test the effect of an acidic solution on the germination of seeds. They originally wanted to test the effects on plants used in revegetation efforts, but did not have the time necessary to see any visible effects. They were able to apply the results they observed in other instances in which acid rain or acid solutions get into the soil.

2. Radish seeds were placed into petri dishes and watered with solutions of different pH. Results were checked daily for evidence of germination.

3. Students in one of the groups read about the relationship between sulfur dioxide in the air and the production of acid rain. The Copper Basin video also talked about high levels of sulfur dioxide remaining in the air. One group decided to test air samples for levels of sulfur dioxide and related its results to the pH of rainwater samples. Through the Internet, students exchanged data with other students who performed similar investigations and confirmed the correlation between the presence of sulfur dioxide and acid rain.

4. Maps of acid rain distribution can be used to help summarize both activities.

5. Students should relate the results of the seed germination lab to the original issues raised in the Copper Basin video.

# The Effect of Fertilizer on the Growth of Plants

## LESSON 6

**Objectives:**

- To examine the nitrogen cycle.
- To relate the results of the soil tests to the growth of plants in an environment.

**Materials:**

Nitrate fertilizers
Seedlings
Sterile potting soil
Small cups
Rulers

**Procedure:**

1. While reading about abiotic factors, students learned about nutrient cycles including the nitrogen cycle. Based on the results of the chemical tests on the soil, it was apparent to them that a lack of appropriate soil nutrients is part of the Copper Basin revegetation problem. Students devised an experiment to test the effect of fertilizer on the growth of plants. *A sample experiment can be found in the student section.*

2. The students discovered that fertilizers are harmful when in excess, but in the correct amounts, are necessary for plant growth. It is surprising how many students could not relate what they had read about the nitrogen cycle to the actual growth of plants.

3. Students related the results of their experiments to the Copper Basin issue.

# Preparing the Presentation

## LESSON 7

**Objectives:**

- To compile and organize the data from student investigations.
- To prepare a presentation based on student-developed criteria that addresses the issues of the Copper Basin.

**Procedure:**

1. I found that having the students summarize that data in a manner of their own choosing worked best. They presented charts, posters, booklets, and even videos.

2. Students determined that they had to relate experimental evidence to the issues and problems presented in the video and to other real-world mining situations. It was easy for the students to make this connection because the charts made in the first lesson were still hanging in the room.

3. Students developed the rubric that was used to score their work.

# Application of Data

# LESSON 8

**Objectives:**

- To gather information about local open pit gravel mines;
- To relate data from investigations to an actual mine;
- To share data with students in another area that has a different type of open pit mining;
- To discuss the environmental impact of other kinds of mining operations.

**Materials:**

Map of county where the mine is located
Speaker and/or video from a mining corporation
An internet link with school in a mining area
Map of the linked area

**Procedure:**

1. A local mining corporation may be willing to provide a speaker on request and may also provide a video of their operations. A gravel mine was contacted in our situation.

2. Soil samples from the mined area can be provided by the company upon request.

3. Over the internet, classes can share data about mines with a school in another area. In our example, the students in Western Pennsylvania were studying the impact of the strip mining of coal on the environment, and shared their data.

# CONCLUDING REMARKS

The students investigated three different mining operations and were able to draw parallels and form conclusions about the impact of mines on the environment. They studied:

- chemical soil content and nutrient cycles
- acid rain and its effects
- habitat destruction
- soil depletion
- the effects of chemicals on the germination of seeds

Throughout the unit the emphasis was on analyzing experimental results and applying them to the Copper Basin problem. As a culminating activity, students applied the results of their investigations to local mining operations.

At times, sequencing and pacing had to be adjusted due to factors such as weather and school schedules. However, students felt responsible for their own learning and employed scientific skills, processes, and concepts to solve a problem.