MONITORING AIR QUALITY
TEACHER LAB TEMPLATE

Dr. Angela C. Morrow

University of Northern Colorado

This lab was produced using the design format developed by the Environmental Literacy Council's educator advisory group with funding from the Department of Education's Fund for the Improvement of Postsecondary Education (FIPSE).

Permission to Reprint Statement

The Advanced Placement Program intends this publication for non-commercial use by AP teachers for course and exam preparation; permission for any other use must be sought from the AP Program. Teachers may reproduce this publication, in whole or in part, **in limited print quantities for non-commercial, face-to-face teaching purposes**. This permission does not apply to any third-party copyrights contained within this publication.

When educators reproduce this publication for non-commercial, face-to-face teaching purposes, the following source line must be included:

> **Monitoring Air Quality, Teacher Lab Template. Copyright © 2003 by the College Entrance Examination Board. Reprinted with permission. All rights reserved. www.collegeboard.com.**
>
> **This material may not be mass distributed, electronically or otherwise. This publication and any copies made from it may not be resold.**

The AP Program defines "limited quantities for non-commercial, face-to-face teaching purposes" as follows:

Distribution of up to 50 print copies from a teacher to a class of students, with each student receiving no more than one copy.

No party may share this copyrighted material electronically — by fax, Web site, CD-ROM, disk, e-mail, electronic discussion group, or any other electronic means not stated here. In some cases— such as online courses or online workshops — the AP Program may grant permission for electronic dissemination of its copyrighted materials. All intended uses not defined within "***non- commercial, face-to-face teaching purposes***" (including distribution exceeding 50 copies) must be reviewed and approved; in these cases, a license agreement must be received and signed by the requestor and copyright owners prior to the use of copyrighted material. Depending on the nature of the request, a licensing fee may be applied. Please use the required form accessible online. The form may be found at: http://www.collegeboard.com/inquiry/cbpermit.html. For more information, please see AP's Licensing Policy For AP® Questions and Materials.

Correlation To Topic Outline In Course Description

- The Atmosphere
- Environmental Quality
- Global Changes and Their Consequences
- Environment and Society

Correlation To National Science Education Standards

1. Scientific Method
2. Physical Science
3. Biological Science
4. Earth Science
5. Technology

Materials

Scrubber Materials

Bituminous coal
Burning chamber
Scrubber chamber
Calcium oxide
Calcium carbonate
Spray bottles
Black or brown paper (grocery bag is fine)
Fans
Vacuum pump and tubing
Balance
Spatula
Butane lighter
Lighter fluid

Ambient Air Pollution Dectector

Sulfur Dioxide

Graph Paper
Clipboard/pencil
Measuring tape
Lichen key

Ozone

Filter paper (10 cm or larger)
Hole punch
Medium paintbrush
Plastic bags
Distilled water
Potassium iodide
Cornstarch
Sodium thiosulfate
Ornament hangers or string
Eco Badges (Eco Badges are available from Vistanomics, Inc., listed below.)

Particulates

Roll of pet hair removal tape
Cellophane tape
Blue index cards
Microscope slides and cover slips
Bacterial/fungi media (optional) (Carolina Biological, http://www.carolina.com)
Key of common fungi and bacteria (optional)

Suppliers

- Vistanomics, Inc., 230 N. Maryland Ave., Suite 310, Glendale, CA 91206- 4261, (818) 409-9157 (Eco Badges)
- Carolina Biological: www.carolina.com (media, coal)

Safety And Disposal

- All burning should be performed under the hood.
- Care should be taken when using lighter fluid.
- When measuring calcium carbonate or calcium oxide, students should wear safety glasses and be careful not to breathe dust. You may choose to have them wear gloves while performing this experiment.
- Students should wear gloves when preparing ozone detectors.

Introduction

Degrading air quality due to motor vehicles convinced the California legislature to enact the first air pollution laws in the U.S. in 1947. The results of this law were to establish air pollution control districts and, in 1960, to require air pollution control devices on cars. In 1970, the U.S. government passed the Clean Air Act, establishing the National Ambient Air Quality Standards (NAAQS). The act set standards for maximum allowable concentrations of particular pollutants for a particular distance from a source in a particular time period. This act was helpful but not perfect, and it resulted in some silly solutions such as simply building a taller smokestack. Of course, building a taller smokestack isn't a solution, and amendments to the Clean Air Act have addressed some of these problems by dealing with annual emissions of particular pollutants. The good news is that there has been a major reduction in many pollutants; however, increases in population and in the number of cars have prevented a significant reduction in some pollutants such as carbon and nitrogen oxide.

One of the most important components of industrial air pollution control is scrubbers for the removal of sulfur. As any protein or protein-derived product burns, sulfur is emitted. Scrubbers remove the sulfur from the emissions by spraying a solution of calcium oxide or calcium carbonate into the stream of gas coming from the combustion chamber. The reaction between the sulfur and the calcium compound produces calcium sulfite or calcium sulfate, which is commonly known as gypsum. Gypsum is used in the production of cement, plaster, and wallboard. In fact, in Japan, where there are no deposits of gypsum, it is collected from scrubber units and used in these products.

The types of pollutants in the air are numerous and vary in chemical composition; therefore, our definition of air pollution must reflect this multiplicity. Additionally, we must test for air pollutants in a variety of ways in order to come to a more realistic picture of air quality.

Group Size

- Classroom groups of four

Lab Length

- Scrubbers: One to two class periods
- Assessment of air quality: one class period to prepare detectors, two half-periods to distribute (or out-of-class time)

Preparation and Prep Time

- Use *Easy Breathers* video before lab (free copies from www.easybreathers.org).
- Lay out materials for easy access. Depending on time available, the teacher may prepare ozone detectors and particulate detectors before the lab.
- Prepare map of student grids for air quality assessment.
- Students will need time either in class or out of class to review the principle of a scrubber and to access information on commercial scrubbers. Design of the scrubber might be an out-of-class assignment.
- Students may perform air quality work outside of class.
- If students report results to class, an additional class time should be planned.

Teaching Tips

General Tips:

1. There are no correct designs for the student scrubbers. The students need a burn chamber, a scrubber chamber, and a method to get the calcium oxide or carbonate solution to the gas being emitted by the burning coal. A couple of sample designs are attached. Allow students to resolve the issue of the efficiency of their scrubber. For example, it may be sufficient to collect the precipitate on dark paper and declare this the results of the scrubber. Those who have had chemistry may be able to determine that CaCO3 should neutralize acid. So if all they have precipitated is CaCO3, then it should neutralize lemon juice and therefore could be tested with pH paper.

2. Allow students to design their own scrubbers, but check carefully before they are used for safety concerns.

3. Place scrubbers on a fireproof surface before the burn. Burn under a hood if possible.

4. If possible, show students samples of lichen type before the laboratory.

5. Have a lichen key on hand for lichen observation.

6. Add sodium thiosulfate to ozone detection paste if blue occurs before detectors are exposed to ozone. The reaction will not take place in O2.

7. The easiest way to prepare the paste and dry the detectors is in a microwave oven.

8. Detectors can be made ahead of time and placed in a plastic bag for storage up to a week ahead of time.

9. Pet hair removal sheets are stickier than lint removal sheets.

10. A key or photographic atlas with various types of microorganisms displayed is helpful.

11. You may need to add a starter fluid (e.g., the barbeque type works) to get coal to start burning.

12. See AP Central for more information on surveying an area with a grid.

Potential Problems:

- Weather
- Unable to get coal to burn
- Pre-exposure bluing of ozone detectors
- Sulfur content of coal
- Inaccurate measurements

Possible Variations:

- Plate particulates on nutrient agar.
- Visit commercial plant with scrubber or have an industry speaker.
- Use Earth Algebra text to integrate mathematics and science. This text provides practice in algebra with environmental application problems.
- Compare in-class data.
- Compare derived data with official reported data.

Sample Data

- See scrubber designs above.
- Eco Badge kit comes with a key for ozone exposure. Class-made ozone detectors will turn darker with more ozone exposure. It is possible to correlate the data from the Eco Badges and the ozone detectors.
- Lichen survey results will vary with locations, but be aware that there are some areas of the country that have little to no lichens growing; therefore, this portion of the lab might not be appropriate.

Post Lab Analysis

- Following group reports, have students discuss their results and evaluate the overall air quality.
- Present an inventor award for best design or working scrubber.

Discussion Questions:

1. Discuss the quality of commercial scrubbers and feasibility of improving them.

2. Why/why not would it be useful to require industries to reuse gypsum? How might that be put into effect?

3. Discuss the usefulness of lichens in monitoring air quality. What pollutant are lichens most sensitive to?

4. What would be the commercial value of Eco Badges?

5. How well did the data from the Eco Badges correlate to the data from the ozone detectors? Why?

6. Were you surprised at the amount of particulates in the atmosphere?

7. How are particulates introduced into the air? What are some natural sources of particulate matter?

8. List some reasons for publishing or releasing information on particulates in the atmosphere to the general public.

Possible Assessments

Written report or presentation of the following. This might also be displayed on a poster.

Your report on this laboratory should include the following:

a. Design of scrubber and explanation of how it functions
b. Results of scrubber trial and comparison to commercial scrubbers
c. Map of lichen distribution and assessment of air quality
d. Mounted Eco Badge strip and determined results
e. Map of ozone detectors and results
f. Map of particulate collectors and results
g. Illustrations of particulates from microscope observations
h. Analysis of air quality
i. Problems (equipment, weather, etc.)
j. Other

Grading Base

- Functional design of scrubber
- Correlation of scrubber to content of sulfur in coal sample
- Accuracy and readability of lichen map
- Correct conclusion from lichen map
- Accuracy and readability of ozone detectors
- Correct conclusion from ozone detectors and correlation to Eco Badge
- Readability and comprehensiveness of particulate map
- Accuracy of microscopic observations
- Accurate interpretation of data
- Reasoning skill in applying interpretations
- Example rubric

References / Resources

Schaufele, C., and N. Zumoff. *Earth Algebra*, 2nd ed. Addison Wesley/Benjamin Cummings, 1999.

Merritts, D., A. De Wet, and K. Menking. *Environmental Geology*. W. H. Freeman, 1997.

www.epa.gov (general info)

www.naaee.org (general info)

http://www.uwstout.edu/chemistry/ondrus/manual/pdf/experiment17.pdf (measuring sulfur (content in coal)

www.madsci.org/posts/archives/dec97/878173221.Ch.r.html (ozone)

http://nasaexplores.com/lessons/01-021/index.html (green airplanes)

www.BuildingGreen.com (green construction)

www.sciencedaily.com/releases/2002/12/021226072410.htm (lichens)

http://geology.uvm.edu/morphwww/giv/2002/summer02/upland/lichen.html (lichens)

www.colostate.edu/Depts/Entomology/courses/en570/papers_1996/simonson.html

(lichens and lichen-feeding moths)

www.dnr.state.wi.us/org/aw/air/MONITOR/bioweb/biohome.html (lichens)

www.umweltbundesamt.de/whocc/AHR10/content2.htm (lichens)

www.nybg.org/bsci/lichens/lichen.html (lichens)