



# MONITORING AIR QUALITY STUDENT LAB TEMPLATE

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## Abstract

Due to air quality laws requiring the reduction of air pollutants and development of such products as air scrubbers, the amount of pollution in our air is less than has been in several decades. However, most of us do not live in an area where the air quality would be considered "very clean and pure." In fact, we live in areas with varying air quality. During this laboratory exercise, you will design and build an air scrubber and assess air quality in a designated area.

## Objectives

- At the end of this lab, you will be able to describe and discuss several air pollutants and methods for detecting them.
- At the end of this lab, you will be able to describe the chemical reactions behind how several monitoring systems function.

## 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.

## Background Research Links

[www.epa.gov](http://www.epa.gov)

[www.naaee.org](http://www.naaee.org)

<http://www.uwstout.edu/chemistry/ondrus/manual/pdf/experiment17.pdf>

## 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 Detection

#### 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

#### Particulates

Roll of pet hair removal tape  
Cellophane tape  
Blue index cards  
Microscope slides and cover slips  
Bacterial/fungi media  
Key of common fungi and bacteria

## Procedure

### Part One

Your assignment is to design and build a scrubber for cleaning the sulfur emissions of burning coal. You can assess how well your scrubber works by collecting the calcium sulfate or sulfite and checking the amount against the known sample sulfur content. A Web site is given to provide you with more background on commercial scrubbers, but this laboratory exercise allows you to use your knowledge of the subject and your creativity to produce a workable scrubber.

After you have designed your scrubber, have it checked out by your instructor and then proceed to build it. Do not breathe in dust from the chemicals. Have the apparatus checked by your instructor. Under the hood, proceed to add lighter-fluid-soaked coal to the burn chamber. With your instructor's supervision, burn the coal and evaluate your scrubber for its efficiency.

### Part Two

Your assignment is to sample your designated grid for particulates, ozone, and general air quality.

#### Lichen

1. Identify a tree closest to the center of your grid and measure its diameter at chest height.
2. Map the lichens from the chest-high mark to the base of the tree, identifying the type (crustose, foliose, fruticose) of lichen and indicating the size of the lichen patch.
3. Using the modified Hawksworth and Rose Index below, determine the relative air quality.
  1. No lichens present (very poor).
  3. Crustose lichens only (poor).
  6. Leafy and crustose lichens (moderate to good air).
  9. Foliose, leafy, and crustose lichens present (good air).
  10. Foliose lichen *Usnea articulata* (string of sausages) (very clean air).
4. Record your results.



crustose



foliose



fruticose

## Ozone

### *Eco Badge*

Wear your Eco Badge indicator per manufacturer's instructions while you are working in your grid. Record your results.

### *Indicator Paper*

1. Prepare a set (suggested 5 to 10 papers) of ozone indicator papers in the following manner:
  - a. Mix 2 grams of potassium iodide, 10 grams of cornstarch, and 100 ml of water. Heat to form a paste. Wear gloves while making this paste and applying it to the filter paper.
  - b. Trying not to touch the surface of the filter paper, punch a hole in the paper to allow for hanging. Then brush a coat of the indicator paste on the surface of the filter paper. Allow to dry. Best results are by microwaving for approximately one minute or baking in an oven at 300 degrees until dry.
2. Using ornament hangers or string, hang a set of detectors at random points in your grid and allow them to hang for 24 hours.
3. Map the location of your indicators within your grid.
4. Remove hangers and check for changes in coloring. The indicator turns blue in the presence of ozone. A darker color indicates higher ozone levels.
5. Record your results.

Compare the results of your Eco Badge with your indicator papers.

## Particulates

1. Prepare particulate collectors by gluing a strip of cellophane tape and a strip of pet hair removal tape on a blue index card. Holes may be punched and hangers added (as in previous experiment).
2. Place cards in random areas of your grid and map the location of your collectors.
3. After a predetermined time, remove your cards and record their appearance.
4. Prepare one or more wet mounts using scrapings obtained from your collection cards.
5. Examine your wet mounts under the microscope and record your findings.

Further study: Particulates may be scraped onto plates with nutrient media. After incubating for 24 hours, check for bacterial or fungal growth.

## Lab Tip

As several oxidizing agents (e.g.,  $\text{NO}_2$ ) can cause bluing, 1 gram sodium thiosulfate may be added to the paste to prevent premature bluing.  $\text{O}_2$  will not cause bluing.

## Data/Observations

### Part One

Provide a diagram of your scrubber and describe how it would function. If the chamber was tested, determine how effective it was based on the amount of calcium sulfate or sulfite produced and the percentage of sulfur contained in the original sample.

### Part Two

Designate a method to indicate the type of lichen found on your sample tree and prepare a map of the lichen distribution.

Match the color of your Eco Badge with the ozone level and record the results.

Draw a map of the hanging ozone detectors and indicate the color results. Be sure you indicate on your map the outlying areas that might have an effect on the level of ozone — e.g., streets, parks, loading zone, etc.

Draw a map of the particulate collectors and indicate the results from the collectors. Draw illustrations of the particulates that you observed under the microscope.

## Analysis

### Part One

How well did your scrubber function? Compare your scrubber results to those of commercial scrubbers.

### Part Two

Based on the data you collected from your grid, what is your conclusion of the air quality of the area? Indicate features in your grid or surrounding your grid that would affect the air quality. How well did the data you collected from the different types of samples agree? For example, did the levels of ozone indicated on your Eco Badge agree with the data from your hanging detectors?

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

## Additional 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](http://www.epa.gov) (general info)

[www.naaee.org](http://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](http://www.madsci.org/posts/archives/dec97/878173221.Ch.r.html) (ozone)

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

[www.BuildingGreen.com](http://www.BuildingGreen.com) (green construction)

[www.sciencedaily.com/releases/2002/12/021226072410.htm](http://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](http://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](http://www.dnr.state.wi.us/org/aw/air/MONITOR/bioweb/biohome.html) (lichens)

[www.umweltbundesamt.de/whocc/AHR10/content2.htm](http://www.umweltbundesamt.de/whocc/AHR10/content2.htm) (lichens)

[www.nybg.org/bsci/lichens/lichen.html](http://www.nybg.org/bsci/lichens/lichen.html) (lichens)