Field-Testing *for* OZONE

Analyzing air quality in your hometown

YELLOWISH-BROWN CLOUDS HANG over our school on hot, calm days—reminders of nearby chemical and oil production plants. Students recognize this air quality problem and have also noticed an increase in headaches, sinus problems, and chest congestion on these days.

After learning that ground-level ozone can oxidize tissue in the respiratory systems of animals, promoting scar tissue formation and cell damage (Linvill, Hooker, and Olson, 1885), students questioned whether the yellowish-brown clouds were caused by ground-level ozone and whether they are related to the increase in respiratory problems. Using a National Center for Atmospheric Research teaching module as our guide, we developed a project to teach students how to measure ground-level ozone and determine ozone concentrations. The students have taken the project a step further by researching the effects of ozone exposure and discussing ways to clean up the problem.

DESIGNING THE TEACHING MODULE

As part of a National Science Foundation teacher enhancement program, scientists at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, and 40 middle school teachers from around the country collaborated to design classroom activities that demonstrate important atmospheric science concepts. Teachers from Texas, California, North Carolina, and Colorado spent the past three summers at NCAR participating in Project Laboratory Experience in Atmospheric Research at NCAR (Project LEARN). One area of research that was of great interest to some of the teachers was the measurement of stratospheric and tropospheric ozone and the significance of those measurements. Because stratospheric ozone measurements are taken by satellites, and because that data is available through NASA and the World Wide Web (see Note on page 18), these teachers turned their attention to measuring tropospheric, or ground-level ozone.

Christian Frederick Schoenbein discovered ozone in 1839 during his tenure as a professor at the University of Basel, Switzerland. He used the reactivity of ozone to measure its presence and prove that it is a naturally occurring component of the atmosphere. For our ozone measurements, we adopted his method of coating filter paper by using a mixture of starch, water, and potassium iodide to measure tropospheric ozone. The paper, called Schoenbein paper, changes color when ozone is present. Ozone causes iodide to oxidize into iodine, which then reacts with the starch, staining it a shade of purple. The darker the color, the more ozone is present.

After working with NCAR scientists and an undergraduate student, the procedure was redesigned for

BY JUDY LEE AND JOYCE DeRULLE

classroom use by ozone module teachers, and we took it back to the classroom for the true test.

RESEARCH AND RESULTS

After a class discussion about the difference between tropospheric and stratospheric ozone, students took home prepared Schoenbein paper to test different locations in the Texas City area for ozone. (See Student Activity on page 19.) I knew results would vary based on the amount of oxidants and relative humidity at each site, but I wanted students to return to class the next day to compare their results with those of other students and make these "discoveries" themselves.

Results are calculated by first determining the Schoenbein number Students match their colored test strip to the Schoenbein Color Scale (Figure 1). In every case, the Schoenbein paper indicated that ozone was present To determine the concentration of ozone in parts per billion (ppb), students then refer to the Relative Humidity Schoenbein Number Chart (Figure 2). The students plotted their findings on a map of Texas City using dots color-coded to represent ozone concentration. This map provided visual evidence of various ozone concentrations across the city

We compared our findings with those of the monitoring stations of the Air Quality Control Board (AQCB) in Texas City and found the Schoenbein ozone test paper to be a fairly reliable testing device. We averaged students' results to produce a daily ozone concentration reading The AQCB monitoring system is hourly, and their results were averaged to determine an overall number for the days tested in order to make a valid comparison. The class's results were within 20 ppb of the readings collected by the AQCB monitoring system. According to the AQCB, concentrations of ozone are high all along the Gulf Coast partly due to channels of ozone moving from the southeast Atlantic coast of the United States westward through Texas to the northwest part of the state.

A COMMUNITY ISSUE

Because of their work with the ozone study, students created community awareness of the ozone problem Because the assignment was conducted at home, parents and siblings were involved in helping students with weather readings from television weather reports The neighboring elementary school was also tested for ozone, and the school district publicized the project and its findings in the local newspapers. Students also e-mailed their results to scientists at NCAR. The scientists applauded the students' efforts.

Personal involvement made the problem real for these students and their families The project gave new meaning to The Clean Air Act for our classes, and many students felt compelled to write to the president, vice president, governor, state representatives, and NASA to find out what was being done to help clean the air They wanted to test the space shuttles to see if ozone was present because of the electrical equipment on board They wanted to know more about what is in the air we breathe and felt a responsibility to help keep the air clean.

THE PROJECT CONTINUES

The students plan to continue the ozone project and expand it by sharing results with other schools and communities. Initially we will work with other Project LEARN teachers and their classes in Alaska, North Carolina, California, and Colorado. Our long-term plans include broadcasting our local weather on a Houston television station and connecting our school with other weather station sites. Once the station is up and running, we plan to have a computerized air monitoring system for Texas City and surrounding communities.

Possible extensions for the ozone project include having students collect daily samples for one week, plot the data on an area map, and graph the ozone concentration using the vertical and horizontal axis of the Relative Humidity Schoenbein Chart. The students can see any day-to-day variation by comparing their daily readings and graphing the results. By comparing the graphs, students can determine consistency in their data and theorize about why results are, or are not, consistent. The data can also be compared against temperature, relative humidity, clouds, wind, rain, and so on.

Another logical extension is to contact the local and state Air Quality Control Board and request data for the test period. Do your readings agree with those from the control board? How large was your sampling? Incorporate science students from other grades or other schools to help obtain as many readings as possible. Compare your results with students' results from other schools, cities, or states to see if there is a correlation or a pattern. These ozone activities help encourage students' learning and communication skills, and serve as a way to promote the importance of protecting the Earth. ✧

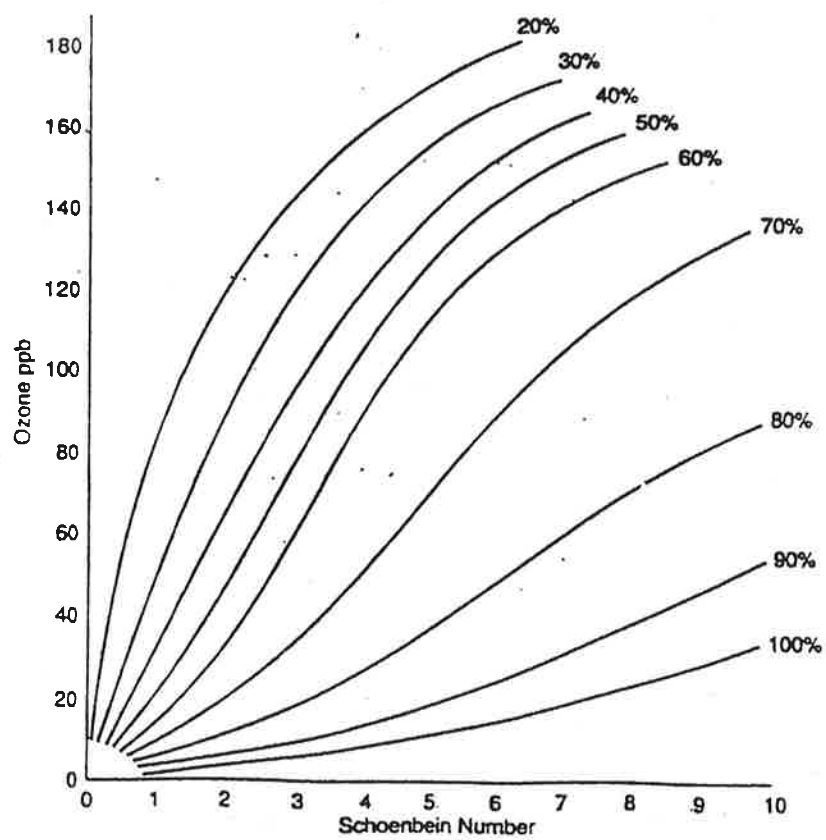
FIGURE 1.

Schoenbein Color Scale.

0–3	Little or no change
4–6	Lavender hue
7–10	Blue or purple

FIGURE 2.

Relative Humidity Schoenbein Number Chart.



Judy Lee is a science teacher and Joyce DeRulle is an English teacher at Blocker Middle School, 500 14th Ave. No., Texas City, TX 77590. E-mail Judy Lee at judyl@tenet.edu.

NOTE

The module Ozone in Our Atmosphere *will be available sometime during the 1995–1996 school year via the National Center for Atmospheric Research's World Wide Web education home page at Internet address:* http://home.ucar.edu/ucargen/education/learn.html *The module is currently available by writing to Carol McLaren, Project LEARN, National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307-3000.*

REFERENCES

Linvill, D. E., W. J. Hooker, and B. Olson. 1885. Ozone in Michigan's environment 1876–1880. *Monthly Weather Review* p. 108.

Mankin, W., A. Weinheimer, K. Davis, and N. Fukushima. 1994. Ozone in Our Atmosphere. A draft module developed by Project LEARN teachers during the summers of 1993–1994 at the National Center for Atmospheric Research.

STUDENT ACTIVITY

Background Information...................
This test is based on the oxidation capability of ozone. Ozone in the air will oxidize the potassium iodide on the Schoenbein paper to produce iodine. The iodine reacts with starch and produces a purple color. The exact shade of purple correlates to the amount of ozone present in the air. The two reactions involved are:

$$2KI + O_3 + H_2O \rightarrow 2KOH + O_2 + I_2$$
$$I_2 + \text{starch} \rightarrow \text{starch turns a shade of purple}$$

Materials...................

- Potassium iodide
- Filter paper
- Corn starch
- Glass stirring rod
- Small paint brush
- 250-mL beaker
- Distilled water
- Heat-safe glass plate
- Full-splash safety goggles
- Aprons
- Schoenbein Color Scale
- Relative Humidity Schoenbein Number Chart
- Heat source (preferably a hot plate)
- Hot pad for removing the beaker from the heat source
- 8 1/2 X 11-inch paper for drying filter paper or a 9-inch microwave-safe plate
- Wet-dry bulb psychrometer that uses two nonmercury-filled thermometers

Schoenbein Paper Preparation...................
1. Place 100 mL of water in a 250-mL beaker then add 5 g of corn starch.
2. Heat and stir mixture until it gels. The mixture is gelled when it thickens and becomes somewhat translucent.
3. Remove the beaker from the heat and add 1 g of potassium iodide and stir well. Cool the solution.
4. Lay a piece of filter paper on a glass plate and carefully brush the paste onto the filter paper. Turn the filter paper over and do the same on the other side. Apply the paste as uniformly as possible. The paper can be exposed for immediate testing at this point.
5. Allow the paper to dry. Do not set in direct sunlight. A low-temperature drying oven works best. To save time, place the paper on a microwave-safe plate and microwave for one minute.
6. Cut the filter paper into 1-inch-wide strips. To store the strips, place them in a zipper-lock plastic bag or glass jar out of direct sunlight.

• Wash hands thoroughly with soap, and scrub under fingernails with a brush after working with the potassium iodide mixture.

Testing Procedure...................
1. Dip a strip of test paper in distilled water and hang it at a data collection site out of direct sunlight. Make sure the strip can hang freely.
2. Expose the paper for approximately eight hours. Seal it in an airtight container if the results will not be recorded immediately.
3. To observe and record test results, dip the paper in distilled water. Observe the color and determine the Schoenbein Number using the Schoenbein color scale.
4. Determine the relative humidity of the data collection site by using a bulb psychrometer or local weather data. Round off the relative humidity reading to the nearest 10 percent.(Higher relative humidity makes the paper more sensitive to ozone, and a higher Schoenbein Number is observed. To correct for this, the relative humidity must be determined and figured into the calculation of ozone concentration.) Refer to the Relative Humidity Schoenbein Number Chart. Along the bottom of the chart, find the point that corresponds to the Schoenbein number that you recorded. From that point, draw a line upward until it intersects with the curve that corresponds to your relative humidity reading. To find the ozone concentration in parts per billion, draw a perpendicular line from the Schoenbein number/relative humidity point of intersection to the left side of the chart.

Observations and Questions...................
1. What change in the test paper, if any, did you observe? (The color of the paper may not be uniform. Determine the Schoenbein Number by the color in an area with the most noticeable change.)
2. Compare your test paper to those of other students. Do all the test papers appear the same? (Individual test papers will vary depending on the amount of oxidants at that site. Be aware that false positive results can occur from nitrous oxides in heavy traffic areas.)
3. Was the relative humidity for your test day high or low? (Individual results will vary depending on the specific relative humidity of the site.)
4. Why do you think the test papers did not all appear the same?
5. Would the parts per billion of ozone be the same for a Schoenbein Number of 4 at a relative humidity of 30 percent and 70 percent? (Hint: Refer to the Relative Humidity Schoenbein Number Chart.)
6. Based on the data you collected, do you think this method is a good way to measure tropospheric ozone? Why or why not?
7. Compare data with those from a local monitoring station. Also, if possible get information about the wind direction during your study and determine how it affected your measurements.

Relative Humidity Schoenbein Number Chart